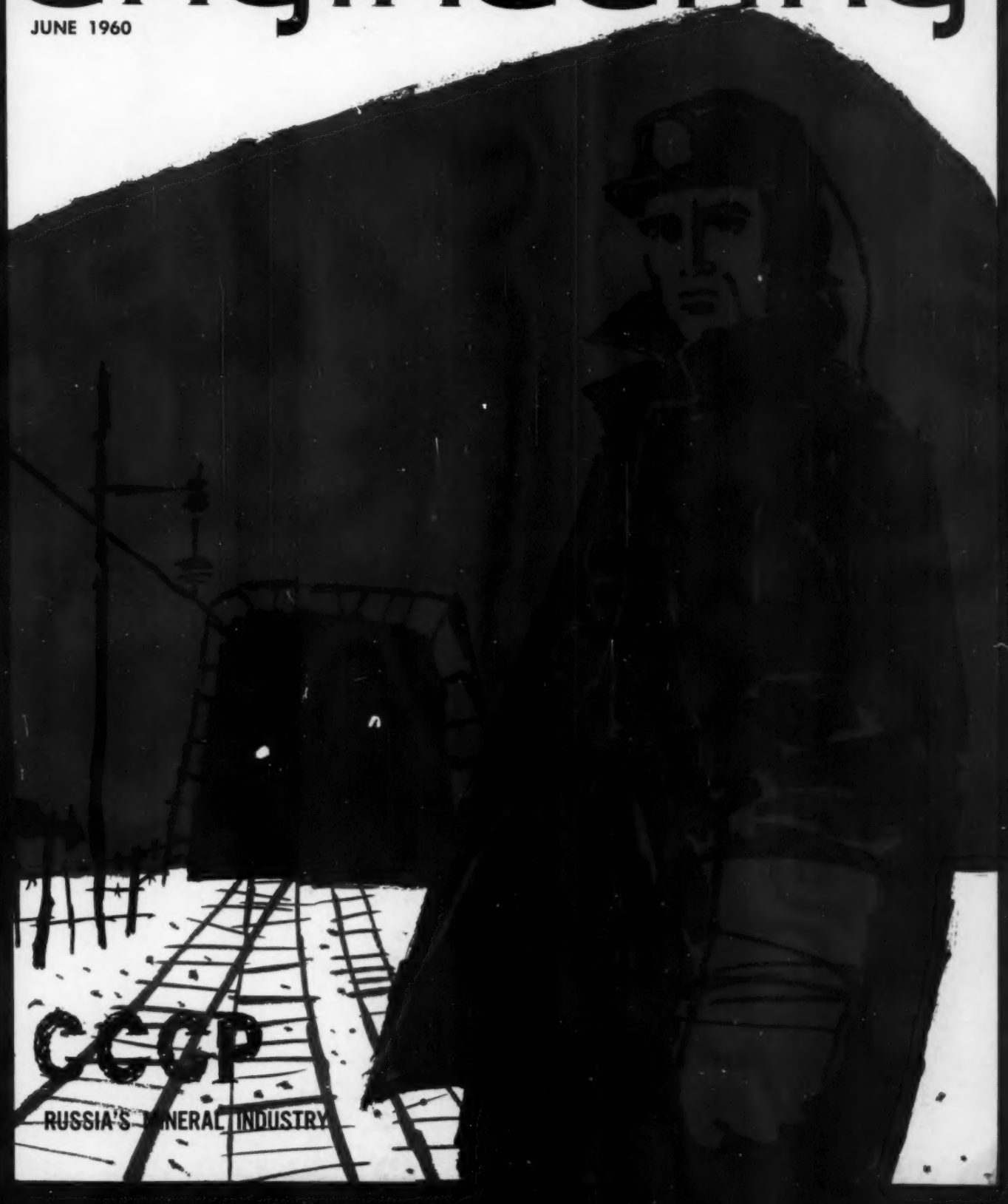
MINING engineering

JUNE 1960



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COMING EVENTS

June 10-11, AIME Central Appalachian Section, spring meeting, Martha Washington Inn, Abingdon, Va.

June 10-11, Wyoming Mining Assn., Jackson Lake Lodge, Wyo.

June 18-19, AIME Colorado Plateau Section, technical meeting, dinner-dance, Ouray, Colo.

June 22-July 1, University of Michigan, practicing engineers' course, "Topics in Multiphase Flow," College of Engineering, University of Michigan, Ann Arbor, Mich.

June 25, AIME Adirondack Section, pit and mill tours at Barton Mines Corp.; dinner, American Tavern, North Creek, N. Y.

July 11-18, 2nd World Conference on Earthquake Engineering, organized by Science Council of Japan in cooperation with Japan Soc. of Civil Engineers, Architectural Inst. of Japan, Seismological Soc. of Japan; Tokyo and Kyoto, Japan.

July 11-20, University of Michigan course, "Applied Mathematics for Chemical and Metallurgical Engineers," College of Engineering, University of Michigan, Ann Arbor, Mich.

July 23, AIME Adirondack Section, plant tour of Reynolds Aluminum operation followed by dinner-program, Massena, N. Y.

Aug. 6-7, AIME Colorado Plateau Section, annual jeep trip.

Aug. 15-25, International Geological Congress, Copenhagen, Denmark; for information, write Mineralogical-Geological Museum, University of Copenhagen, Oster Voldgade 7, Copenhagen K, Denmark.

Aug. 20, AIME Adirondack Section, golf outing followed by panel discussion, program, Tupper Lake, N. Y.

Aug. 22-26, Western Resources Conf. sponsored by University of Colorado, Colorado State University, and Colorado School of Mines on "Water Measuring and Meeting Future Requirements," Lindsley Memorial Courtroom, Fleming Law Building, University of Colorado, Boulder, Colo.

Sept. 8-9, SME Coal Div. and AIME St. Louis Section, joint meeting, Chase Park Plaza Hotel, St. Louis.

Sept. 12-18, International Mining Congress, sponsored by the Hungarian Mining & Metallurgical Soc., Budapest, Hungary.

Sept. 12-16, Pan American Congress on Engineering Education, Buenos Aires, Argentina.

Sept. 15-16, 8th annual Engineering Management Conference, sponsored by AIME, AIEE, AIChE, American Inst. of Industrial Engineers, ASCE, ASME, IRE, Morrison Hotel, Chicago.

Sept. 19-23, 7th Convention of Pan American Assn. of Engineering Socs., Buenos Aires, Argentina.

Sept. 27-Oct. 1, symposium on "Physics of Electrostatic Forces and Their Applications," Laboratoire d'Electrostatique et de Physique du Metal, Institut Fourier, Place du Doyen-Gosse, Grenoble, France.

Oct. 5-7, AIME Rocky Mountain Minerals Conference, Utah Section host, Newhouse Hotel, Salt Lake City.

Oct. 6-8, 9th National Clay Conference, Purdue University, Lafayette, Ind.

Oct. 10-13, American Mining Congress, Mining Show (metal mining-industrial minerals convention, exposition), Convention Center, Las Vegas, Nev.

Oct. 17-18, Symposium on Surface Mining Practices, College of Mines, University of Arizona, Tucson, Ariz.

Oct. 17-19, Drilling and Mining Symposium, sponsored by Colorado School of Mines, Pennsylvania State University, and University of Minnesota, Colorado School of Mines, Golden, Colo.

Oct. 24-25, AIME-ASME Joint Solid Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.

Nov. 4, AIME Pittsburgh Section, Off-the-Record meeting, Penn-Sheraton Hotel, Pittsburgh.

Nov. 7-10, Soc. of Exploration Geophysicists, annual international meeting, Galveston, Texas.

Nov. 18, American Mining Congress, coal division conference, Penn-Sheraton Hotel, Pittsburgh.

Dec. 3, AIME Colorado Plateau Section, technical meeting, election of officers, WAAIME dinner-dance, Grand Junction, Colo.

Dec. 5, AIME Arizona Section annual meeting, Pioneer Hotel, Tucson, Ariz.

Feb. 26-Mar. 2, 1961, AIME Annual Meeting, Chase Park Plaza Hotel, St. Louis.

Apr. 12-14, International Symposium on Agglomeration, sponsored by SME, SPE, and TMS of AIME, Hotel Sheraton, Philadelphia.

Sept. 17-20, Commemoration of the 50th Anniversary of Froth Flotation in the U.S.A., sponsored by AIME: Society of Mining Engineers' Mineral Beneficiation Division, Cosmopolitan Hotel, Denver.

MINING engineering

VOL. 12 NO. 6 **JUNE 1960**

COVER *The mining industry within the USSR is symbolized by artist Herb McClure's portrayal of a Russian miner. Commencing on page 557, the present-day status of Russia's mineral development is described and appraised in a special report by Alexander Gakner, Foreign Specialist in the U. S. Bureau of Mines. Additional data on the USSR appears in the article on page 591.*

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MINING ENGINEERING staff, Society of Mining Engineers, and AIME Officers are listed on the *Drift* page.

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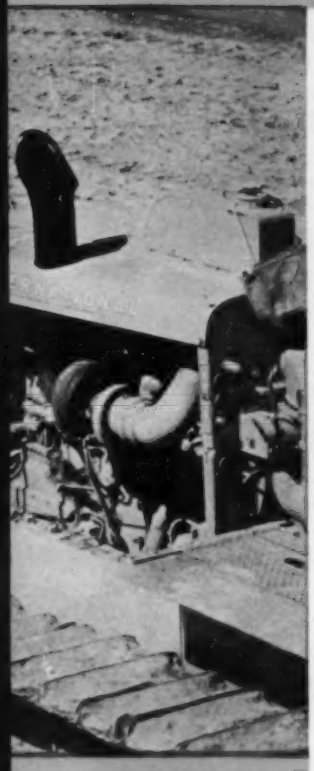

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PERSONNEL

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In addition to the listings below, ESPS maintains a more complete file of general engineering positions and men available. Contract nearest ESPS office, listed above.

MEN AVAILABLE

Minerals Manager, B.S. in geology. Nine years varied business experience in both technical and administrative positions. Thorough knowledge mineral exploration programming and mineral resources studies. Location, U.S. M-537.

Mine Geologist-Engineer, geologist, 31, married. Experienced in all phases of mining from exploration to production. Currently employed as mine foreman. Speak Spanish. Prefer supervisory position in western U.S. or Latin North America. Se-950.

Mine Superintendent, mining engineer, 43. Twenty-three years experience, 12 yrs foreign, in all phases of mining operations; metallic and nonmetallic, placer and lode, open pit, underground, and dredging. Married, no children. Available immediately. $9600 up. Any location. Home: California. Se-1447.

Mine-Mill Foreman, mining engineer, 31. Two years general manager on underground tungsten. Ten months mine foreman underground copper. Two years consultant engineer doing design, planning, development, and plant improvements. $6000. Prefer: Northern California, West. Home: California. Se-1318.

Manager, mining engineer, 40. Sixteen years experience in metal mining, last ten years in top management. Exceptional experience in operations, development, planning, construction, and cost estimating. $12,000. Any location. Home: Michigan. Se-1355.

Mine Superintendent, 56. Licensed in Oregon and Philippine Islands. Thirty years experience in charge of operations, exploration, open pit, underground, construction of camps, facilities, roads for mining companies. $9600. Prefer: Latin American, U.S., Philippine Islands. Home: Canada. Se-1300.

Mine Superintendent, mining engineer, 25. Three years experience mine superintendent, in charge of development and production, survey on Pb-Zn mines. One year quarry engineer trainee for gypsum quarry. $7200. Prefer: Latin America, U.S. Home: Mexico. Se-1102.

Exploration, Mining Geologist, M.S. in geology, 27. Three months mapping, sampling, evaluating limestone prospects; cement manufacturer. Nine months teaching assistant (part time) petrography, petro-logic research. $5000. Prefer: West, foreign. Home: East. Se-1207.

Production or Construction Supervisor, mining engineer, 34. Ten years experience including top level resource recommendations, production responsibility, complete plant design, construction, and financial management. $9600. Prefer: Northwest. Home: California. Se-1180.

Assistant Superintendent or Foreman. Twelve years experience operation of underground mines, purchase all mining supplies and equipment for quicksilver, mercury mines. $7500. Prefer: U.S., oversea. Home: California. Se-1149.

Geologist, geologist, 28. Two years geologist, mine construction, surface subsidence on salt mining. Five years U.S. Air Force, pilot. One year instrumentman for railroad. $7000. Prefer: West, South, Midwest. Home: Michigan. Se-1113.

Exploration Geologist, geologist, 26. Two years geological examination, evaluation for bauxite and aluminum. Four months recorder, triangulation, mapping; geodetic survey. Three years U.S. Air Force, photographic-radar. $5000. Prefer: Overseas or any. Home: San Francisco. Se-1096.

Designer, Construction Engineer, mining engineer, 31. Speak Spanish. Seven years experience directing reduction pilot plant, construction, survey, mapping, scheduling for steel company. $9000. Any location. Home: Indiana. Se-938.

Superintendent, civil engineering training, 43. Six years superintendent of open pit iron mine including planning, administration, supervising construction facilities, pump stations, pipeline construction for engineer-constructor. One year safety engineer. Two years clear and construct sawmill. Also experienced on construction of towns, dams, sewers, airports, and railroads. $8000. Prefer: Foreign, Northwest. Home: Oregon. Se-947.

Geologist, Mine manager, LL.B. in mining engineering, 53. Regis professional engineer. Thirty-three years experience examination, appraising, managing, supervising design, equipment, production on exploration, mining copper, silver, gold, phosphates, and general legal counsel. $12,000. Prefer: western U.S., Latin and South America. Home: New Mexico. Se-911.

Manager, Superintendent, 53. Thirteen years manager of mines, supervise all production, purchasing, operation, negotiate labor contracts, exploration, and development. Twenty-five years mill superintendent, supervise maintenance, ore dressing operations (lead, zinc, silver, copper, gold, mercury operations). $9600. Prefer: West, U.S. Home: Idaho. Se-903.

Manager, mining engineer, 62. Thirty-six years experience as general manager, superintendent on mills, mines, construction, development, operations, facilities; both domestic and foreign; gold, silver, base metals. $12,000. Prefer: Southwest, U.S. or any. Home: Arizona. Se-864.

Mining Engineer, M.S. in mining engineering from Columbia University. Twelve years experience in Latin American mines—surveying, sampling, ore reserve estimation, computing, mapping; also familiar with industrial hygiene and safety including supervision and administrative work. Fluent Spanish. Location, immaterial. Permanent resident of U.S. under immigrant visa. M-538.

Superintendent or Assistant, B.S. in mining engineering. Nine years experience in engineering, planning, contract negotiation, labor relations, and supervision of open pit mines and quarries. Location, open. M-539.

Geologist, M.S. from New York University. Twelve years experience in petrographic, geological, and seismograph interpretative work. Desires employment in either of above fields or teaching. M-540.

Executive-Operations and Administrative, mining engineer, 43. Impressive management and administrative background in copper, aluminum, and phosphate mining, beneficiation, processing, and chemical industries. Record of accomplishment in facility design and expansion, profits, land utilization, labor relations, administrative functions. Desires challenging position; will relocate. M-541.

(Continued on page 528)

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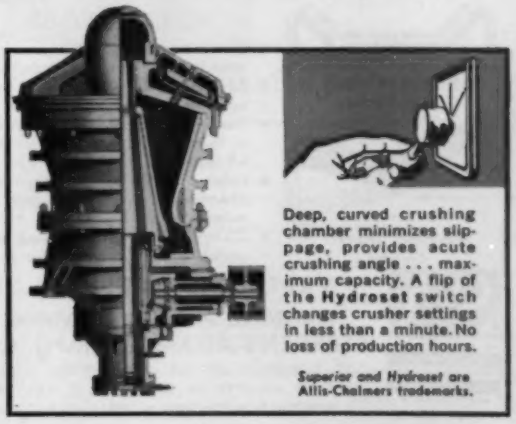

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PERSONNEL

(Continued from page 526)

General Manager or Superintendent, 46. Ten years experience in charge of mine production, surface and underground, exploration both metal and nonmetallic. $12,000. Prefer western U.S. Home: Colorado. Se-1262.

Engineering Geologist, M.S. in geology, 26. Single. Experience in foundation investigation. Desires position in soil mechanics or engineering geology. $6000. Prefer California. Home: California. Se-692.

Mine Superintendent, mining geologist, 49. Twenty-five years experience from miner to manager of operations in all types of mining methods including ten years in block caving. Available now and willing to go anywhere. $8400 plus. Any location. Home: Utah. Se-368.

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Beneficiation Engineer, B.S. or M.S. in mineral, metallurgical, or chemical engineering, with two to five years experience in beneficiation, preferably on iron ores. Laboratory, pilot plant, and operations experience desirable. For process and economic studies of new and existing processes. Location, western Pennsylvania. W8834.

Mining Engineer to handle stope measurements, development measurements, preparation of reports, etc. Salary to start, $5400 to $6000 year. Mine produces about 1000 tpd from underground operations. Location, South. W8415b.

Mining Engineers. a) *Mine Superintendent,* graduate with minimum of five years experience for underground 1000 tpd metal mine. Salary, $12,000 year. b) *Mining Engineers,* recent graduates will be considered for survey, mapping, etc. at metal mine. Salary, to $6000 year. Location, South. W8520.

Mining Engineer, mining engineer, under 30. Experienced in open pit operations; some underground mining helpful. Experienced with gravity and flotation mills; job training for supervisory level. Salary, $6000 to $6600. Midwest. Sj-5122-R.

Mining Engineer, mining engineer, must have open pit quarry experience, including supervisory and engineering abilities and some mechanical engineering knowledge. Salary, $7200 or more. Arizona. Sj-5142.

Resident geologist, mining engineer, geologist, 30 to 40. Minimum seven years experience hardrock mining geology at nonferrous, operating mining properties. Knowledge of Spanish desirable, but not essential. Employer pays placement fee. Salary commensurate with experience. South America. Sj-5149.

Junior Mining Engineer, recent graduate, under 30. For general training as assistant to company geologist, relief for quarry mining engineers, some drafting duties, and some lab work. Overall training program will lead to increased duties and position. Start $6300 plus other fringe benefits. Southern California. Sj-5114.

Junior Mining Engineer, recent graduate, young, for ventilation control, underground mapping, and surveying. Experience in this field preferred (but not necessary). Salary, open. California. S-5154-R.

Mineral Dressing Engineer, for research and process development in industrial mineral fields. Salary, $5400 to $7200 year with liberal vacation, retirement, and other benefits. Location, Southeast. W8932.

Design Engineer, castings, degree in mining and/or metallurgical or mechanical engineering preferred, with considerable experience as process or design engineer, preferably in mining or casting field, for the design of castings of manganese and other wear resistant steel alloys. Salary, $10,000 year to start. Location, Illinois. W8928(a.)

Assistant Vice President, Operations, for large multiplant producer of chemicals and minerals, to 45, engineering background in related industry. Will report to and assist vice president in overall direction and coordination of a number of widely dispersed physical plants engaged in mining and processing inorganic chemicals. Will handle full range of administrative problems with line responsibility. Excellent opportunity. Salary, $20,000-$30,000 year plus additional benefits. Location, Chicago. W8876.

Mine Superintendent, well versed in managing underground and small open pit operations. Should have 8 to 12 years experience, capable of organizing, planning, and executing suitable mining method and have capacity to grow into responsible management position. For small uranium mine. Salary, open; starting date immediate. South Dakota. Sj-5227.

Pilot Plant Superintendent, metallurgical engineer, or mining engineer, 30 to 40. Experienced in pilot plant ore dressing operation (heavy media, jigging, spirals, flotation, magnetic separation) for iron ore operation. Working knowledge of Spanish. Possible family housing after employment, after two to three months single status. For an open pit operation. About $9600 plus benefits. South America. Sj-5210.

Geologist, graduate in mining engineering or geological engineering, or equivalent. Five to eight years experience in geological work preferably with mining company. To do geological investigations, surveying and mapping of solid materials formation, both metals and nonmetals, evaluate mineral resources of all types, and reports. About $6600 or more, depending on experience plus expenses. Willing to work in remote western areas, single or limited family status. One year's duration. Sj-5200.

Senior Industrial Engineers, qualified graduate engineers with good background of experience in industrial engineering field. Positions require proven competency in procedures and techniques for development, installation, and administration of work measurement and incentive programs. Opportunities for qualified and ambitious engineers. Benefits. Headquarters, Utah. Sj-5173-R.

Mechanical Engineer, mining engineering, young, to four years working experience preferred in underground mapping. Able to handle ventilation control and underground mapping and survey. Some mine working experience required plus mechanical experience. For a mining company. To $7200. Central Sierras. Sj-5154-R.

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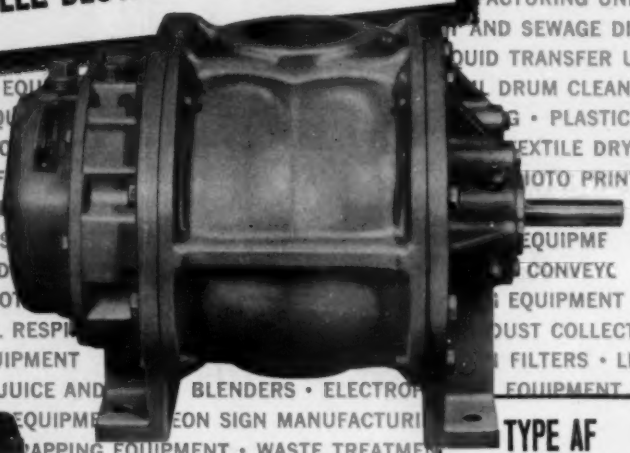

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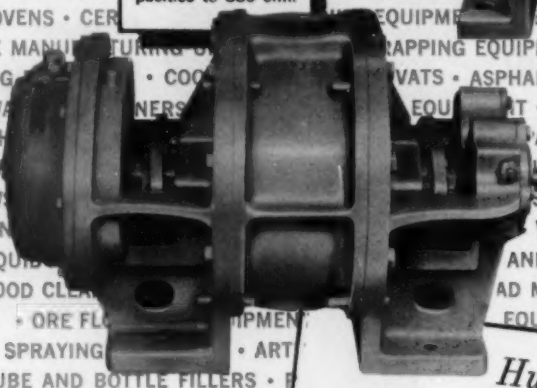

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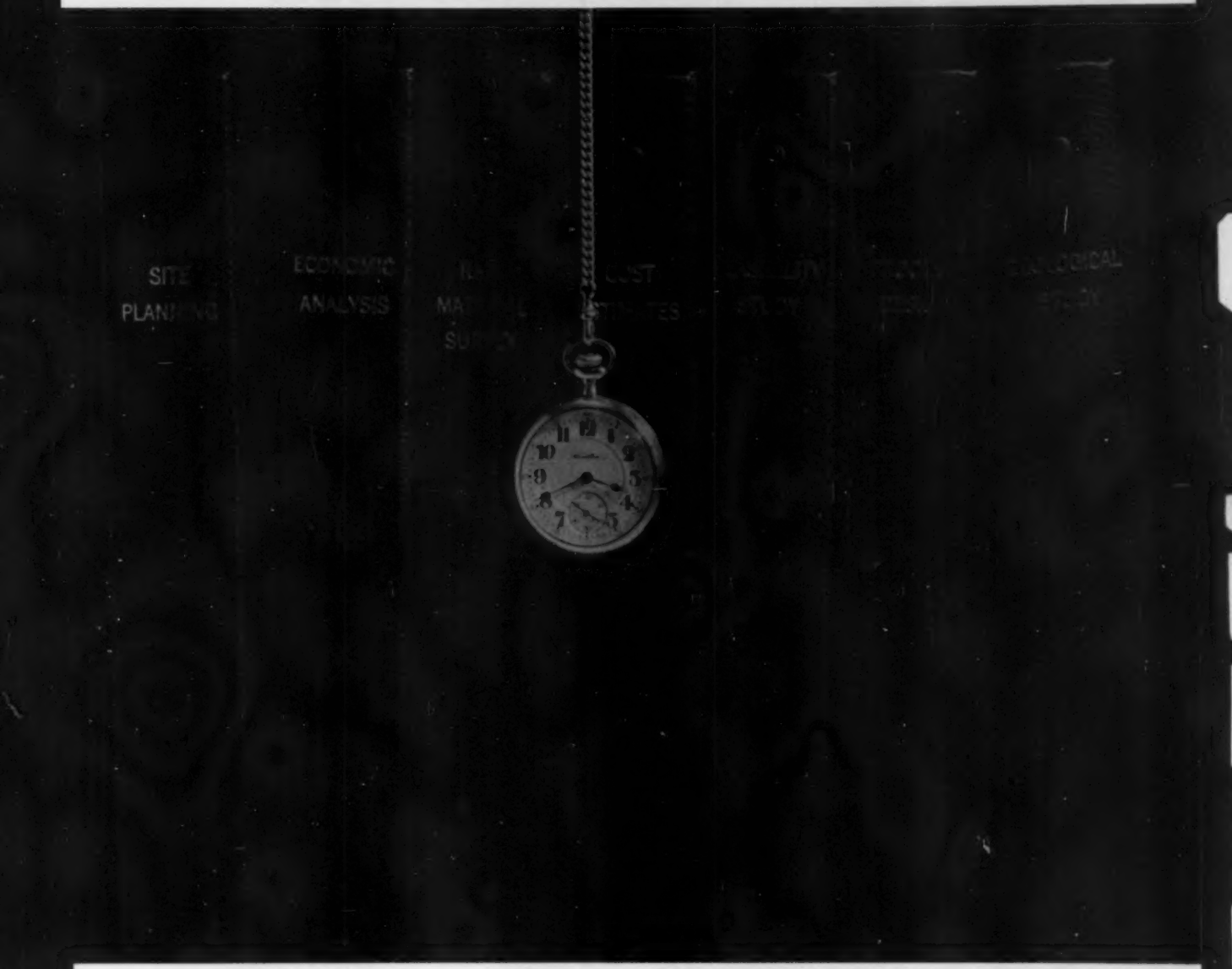

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Arkansas Geological & Conservation Comm.
446 State Capitol
Little Rock, Ark.

Project Water Utilization in Washington and Benton Counties, by Ralph Gray, 1 copy gratis, in quantity 10¢, 1959.

Colorado

Dept. of Publications
Colorado School of Mines
Golden, Colo.

Petrology of the Fountain and Lyons Formations, Front Range, by John F. Herbert, Quarterly of the Colorado School of Mines, Vol. 55, No. 1, $3, 1960.

Idaho

Idaho Bureau of Mines and Geology
Moscow, Idaho

Reconnaissance Geology of the Elk City Region, Idaho, Pamphlet 120, $1.40, 1959.
Ignimbrite Bibliography, Information Circular 4, 1 copy gratis to residents, 25¢ for additional copies and to out-of-state addresses.

Illinois

State Geological Survey
Natural Resources Bldg.
Urbana, Ill.

Visual Estimates of Grain Size Distribution In Some Chester Sandstones, Circular 280, gratis, 1959.
Hydraulic Fracture Theory: Part III—Elastic Properties of Sandstone, Circular 281, gratis, 1959.
Chemical and Spectrochemical Analyses of Illinois Clay Materials, Circular 282, gratis 1959.
Economic Aspects of Direct Reduction of Iron Ore in Illinois, Circular 283, gratis, 1959.
Salem Limestone in Southwestern Illinois, Circular 284, gratis, 1960.
Classification of the Wisconsinan Stage in the Lake Michigan Glacial Lobe, Circular 285, gratis, 1960.
Clay Mineralogy of Pre-Pennsylvania Sandstones and Shales of the Illinois Basin Part I-Relation of Permeability to Clay Mineral Suites, Circular 286, gratis, 1960.
Clay Mineralogy of Pre-Pennsylvania Sandstones and Shales of the Illinois Basin Part II-Clay Mineral Variations Between Oil-Bearing and Non-Oil-Bearing Sandstones, Circular 287, gratis, 1960.

Indiana

Publications Section
Geological Survey
Indiana University
Bloomington, Ind.

Petrographic Similarity of Wisconsin Tills in Marion County, Indiana, Report of Progress No. 15, 50¢ plus 10¢ mailing charge, 1959.
The Mt. Carmel Fault and Related Structural Features in South-Central Indiana, Report of Progress No. 16, 75¢ plus 10¢ mailing charge, 1959.
Fossils: Prehistoric Animals in Hoosier Rocks, Circular No. 7, 40¢ plus 10¢ mailing charge, 1960.

Kansas

State Geological Survey
University of Kansas
Lawrence, Kansas

Graphic Column and Classification of Rocks in Kansas, chart, 10¢ folded, 20¢ rolled in tube, 1960.

Montana

Bureau of Mines and Geology
Room 203-B, Main Hall
Montana School of Mines
Butte, Mont.

Progress Report on Clays and Shales of Montana, 1958-1959, Bulletin 13, gratis, 1960.

New Hampshire

State Planning and Development Comm.
Concord, N. H.

Geology of the Isles of Shoals (Me. and N. H.), $1, 1959.

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State Bureau of Mines & Mineral Resources
Campus Station, Socorro, N. M.

Petroleum Developments in New Mexico Developments in New Mexico During 1958, Circular 52, 50¢, 1959.
Late Pennsylvanian and Early Permian Stratigraphy of the Northern Sacramento Mountains, Otero County, New Mexico, Bulletin 50, $2.50, 1959.
Geologic Studies of Union County, New Mexico, Bulletin 63, $3, 1960.
Mineral Deposits of Lincoln County, New Mexico, Bulletin 67, $2.50, 1959.
Gypsum Resources of New Mexico, Bulletin 68, $1, 1959.
Lined-Cavity Shaped Charges and Their Use in Rock and Earth Materials, Bulletin 69, $1.25, 1959.
Reconnaissance Geologic Map of Mogollon Thirty-Minute Quadrangle, Geologic Map 10, 50¢, 1959.
Little Black Peak Fifteen-Minute Quadrangle, East Half, Geologic Map 11, 50¢, 1959.
Reconnaissance Geologic Map of Reserve Thirty-Minute Quadrangle, Geologic Map 12, 50¢, 1959.

North Dakota

Wilson M. Laird, State Geologist
Grand Forks, N. D.

Structural Geology of the Skaar-Trotters Area, McKenzie and Golden Valley Counties, North Dakota, Report of Investigations 15, 50¢, 1960.

Oklahoma

Geological Survey
Norman, Okla.

The Mineral Industries of Oklahoma in 1957 and 1958, Mineral Report 36, 25¢.

Oklahoma Water Resources Board
Oklahoma City 5, Okla.

Hydrologic and Physical Data for Sandstone Creek Watershed in Western Oklahoma, 1951-1956, Bulletin 17, gratis, 1959.
Water, Oklahoma's Most Precious Resource, an activity report, gratis, 1959.

Pennsylvania

Order From:

Topographic & Geologic Survey
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Geologic Interpretation of Aeromagnetic Maps of the Pottstown, Wagonstown, Downingtown, Coatesville, Unionville, Honeybrook, and Parkesburg quadrangles, Information Circular 37, gratis, 1960.
Geologic Interpretation of Aeromagnetic Maps of the Temple, Fleetwood, Manatawny, Reading, Birdsboro, and Boyertown quadrangles, Information Circular 38, gratis, 1960.
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The Mineral Industry of Pennsylvania in 1957, Information Circular 15, gratis, 1959.
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The History of Chromite Mining in Pennsylvania and Maryland, Information Circular 14, gratis, 1959.

Order From:

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Harrisburg, Pa.

Mineral Collecting in Pennsylvania, Bulletin G33, 15¢, 1960.
The Geomorphology of the Wyoming-Lackawanna Region, Pennsylvania, Bulletin G9, 70¢, 1959.
Clay and Shale Resources in Pennsylvania, Bulletin M23, $1.25, 1959.
The Glacial Geology of Northwestern Pennsylvania, Bulletin G32, $1.30, 1959.
Catalogue of Deep Well Samples and Geophysical Logs to January 1, 1959, Information Circular 16, 35¢, 1959.
The Geology and Mineral Resources of Bucks County, Pennsylvania, Bulletin C 9, $7.25, 1959.
Maps and Circulars of Southeastern Pennsylvania, 50¢ each for the 19 aeromagnetic maps; 18 circulars at no cost; for the maps send to Distribution Section, U.S.G.S., Washington 25, D. C.

South Dakota

Industrial Development & Expansion Agency
Pierre, S. D.

Mineral Resources of South Dakota, by R. H. Miller, gratis, 1959.

Tennessee

Tennessee Div. of Geology
G-5 State Office Bldg.
Nashville 3, Tenn.

Geology of the Buffalo Mountain-Cherokee Mountain Area, Northeastern Tennessee, Report of Investigations No. 9, 25¢, 1959.
The Coal Reserves of Tennessee, Bulletin 63, $3, 1959.

Texas

Bureau of Economic Geology
The University of Texas, University Station
Box 8022
Austin 12, Texas

Stratigraphy of the Pre-Simpson Paleozoic Subsurface Rocks of Texas and Southeast New Mexico, Publication 5924, $7.75, 1960.
Graptolite Faunas of the Marathon Region, West Texas, Publication 6005, $3, 1960.
Correlation of the Ogallala Formation (Neocene) in Western Texas with Type Localities in Nebraska, Report of Investigations No. 39, 75¢, 1959.
Vermiculite in Central Texas, Report of Investigations No. 40, 50¢, 1959.
Geology of Van Horn Mountains, Texas, Geologic Quadrangle Map No. 23, 75¢, 1959.

Washington

Washington Dept. of Conservation
335 General Administration Bldg.
Olympia, Wash.

Fossils in Washington by Vaughn E. Livingston, Jr., 25¢, 1959.
Tertiary Stratigraphic Papers, Southwestern Washington, Reprint No. 3, 25¢, 1959.
Nickel-Gold Ore of the Mackinaw Mine, Snohomish County, Washington, Reprint No. 4, 25¢, 1959.

West Virginia

Geological and Economic Survey
P. O. Box 879
Morgantown, W. Va.

Structural Map of Wirt, Roane and Calhoun Counties, W. Va., $1.06, 1958.
Mineral Resources and Mineral Industries Map of West Virginia, $1.56, 1958.
Ground-Water Resources of Harrison County, W. Va., Bulletin No. 14, $1.08, 1958.
Ground-Water Resources of Monongalia County, W. Va., Bulletin No. 15, $1.11, 1958.

Canada

Government Publications

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Industrial Water Resources of Canada, Water Survey Report No. 9, Cat. No. L3-2005, 25¢.
A Survey of the Law of Water in Alberta, Saskatchewan and Manitoba, Cat. No. A73-1046, $1.
Subsurface Stratigraphy of Upper Cambrian Rocks in Southwestern Ontario, Cat. No. M44-58/12, 50¢.

Dept. of Mines & Technical Surveys
Mineral Resources Div.
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Survey of the Primary Zinc Industry in Canada in 1958, Mineral Information Bulletin MR 32, 50¢, 1959.

Dept. of Mines & Technical Surveys
Mines Branch
Ottawa, Canada

The Story of the Early Days of the Extraction of Helium Gas from Natural Gas in Canada, 1915-1920, Information Circular CI 105, 25¢, 1959.
A laboratory Study on the Agglomeration of Coal in the Presence of Plasticizing Agents At Moderate Temperatures and High Pressures, Technical Bulletin TB 4, 25¢, 1959.

British Columbia

The Deputy Minister of Mines
Victoria, B. C.

Stratigraphy and Structure of the Salmo Lead-Zinc Area, Bulletin 41, gratis.
Annual Report of the Minister of Mines, 1958, paper bound, gratis; cloth bound, $2.50.

Ontario

Dept. of Mines
Parliament Bldgs.
Toronto 2, Ont.

Geological Map of the Province of Ontario, new edition, Map. No. 1958-B, $1, 1959.

Quebec

Dept. of Mines
Hotel du Gouvernement
Quebec, Canada

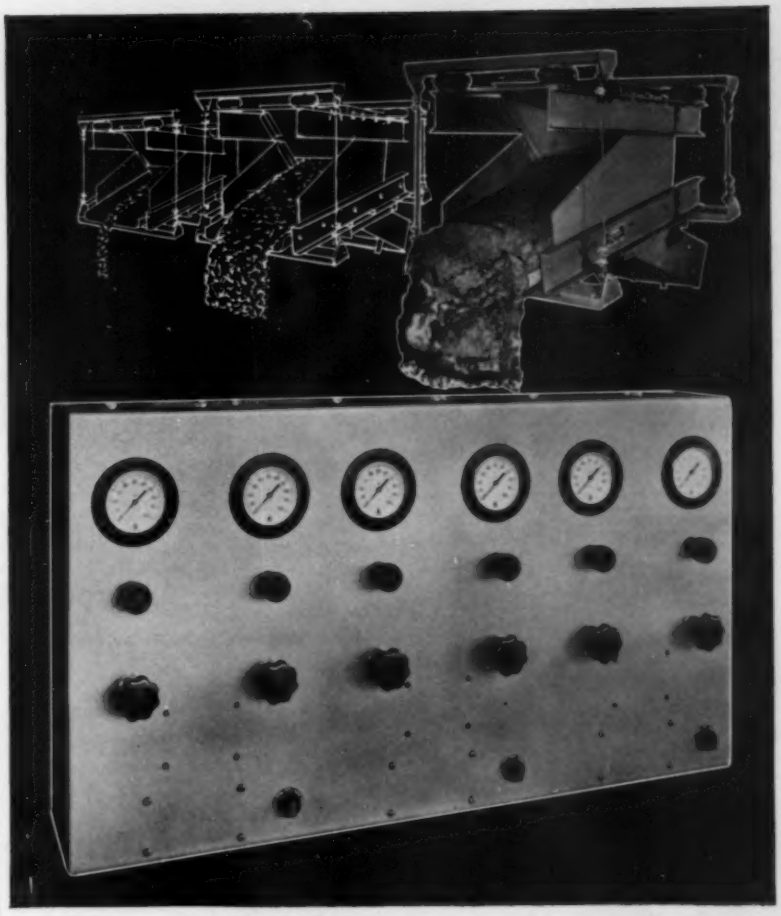
G. R. 84 Fancamp-Hally Area, electoral district of Abitibi-East.
G. R. 85 Brongniart-Lescure Area, electoral district of Abitibi-East.
P. R. 390 Description of Mining Properties examined in 1956 and 1957, by officers of the Quebec Department of Mines.
P. R. 391 McLachlin-Booth Area, Temiscamingue Electoral District.
P. R. 394 Margry-Prevert Area, Abitibi-East Electoral District.
P. R. 392 Povungnituk Range Area, New Quebec. Canadian Mining Manual, $8, 1959; order from National Business Publications Ltd., Gardenvale, Quebec.

Germany

Science of Plan-Drawing and Sketching, Vol. 1, approx. $3.75 (DM 15.60), 1959; order from Bergakademie Freiberg, Roter Weg 41/43, Saxony.

Kenya

Geology of the El Wak-Akus Mandula Area, Report No. 44, approx. $3 (Sh. 17/50); order from Ministry of Commerce and Industry, Geological Survey of Kenya, Nairobi, Kenya.



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ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Minerals and Monopoly-Formula for Soviet Strength by *Alexander Gakner*—Since the end of World War II the U.S.S.R. has made great strides toward economic development. Today it is firmly established as the world's second largest industrial power after the U.S. and has committed itself to catch up with and to overtake us within a few decades. No nation could achieve such a degree of industrialization or aspire to become the world's industrial leader without a large supply of many basic mineral raw materials or at least easy access to such resources. In addition, it requires technical competence, a large skilled labor force, and a high rate of capital investment. In examining the overwhelming evidence of their large-scale activity in the fields of geology, mining, and metallurgy, we must conclude that their mineral policy is based on at least three cardinal principles: 1) maximum knowledge of their indigenous natural resources; 2) maximum self-sufficiency at almost any price; and 3) long-range planning. It is obvious that they are aided in carrying out this policy by the fact that all the participating organizations are a monopoly of the Soviet Government. **Ref.:** (MINING ENGINEERING, **June 1960) p. 557.**

The Need of A New Philosophy of Prospecting, by *L. B. Slichter*—This is the text of the 1960 Jackling Lecture. Looking to the future, it is a good guess that the costs of finding ore will increase in response to increasing technical difficulties. To continue to achieve profits from prospecting, it will become necessary to analyze the business more skillfully, in a more and more sophisticated manner. Without belittling in the least the importance of improving all the tools for finding ore—geological, geophysical, and geochemical—the author urges the primary importance of appraising the *expectations* of finding ore. The vital statistics in prospecting are just as vital to prospectors as are the corresponding vital statistics in the insurance business. Actuarial experts of a new type are needed to compile the needed information and to appraise the risks in prospecting blind. We need to improve the art of comparing prospecting ventures in terms of the odds, in a word in terms of numbers. **Ref.:** (MINING ENGINEERING, **June 1960) AIME Trans., 1960, vol. 217, p. 570.**

Aerial Mapping at Esperanza, by *F. H. Buchella, Jr.*—The use of photogrammetry at Esperanza provided a fast, accurate, and relatively inexpensive method of checking true progress of excavation during premining stripping and early mining phases. Ground mapping on 20-ft contours or less was combined with aerial photography to provide horizontal sections from which the true quantities of excavated material was determined. **Ref.:** (MINING ENGINEERING, **June 1960) p. 566.**

New Safety Program at Chino Mines Div. Steps Up Production, Lowers Costs by *Paul L. Hunter*—Safety is efficiency. Both accident prevention and industrial health programs are vital aspects of sound employment policy. This discussion evaluates the progress made during the 1955-1958 period when the safety and industrial health programs at Chino were reorganized on a more active basis. **Ref.:** (MINING ENGINEERING, **June 1960) p. 568.**

The Grand Isle Mine—Freeport Sulphur Company's Offshore Venture by *C. O. Lee, Z. W. Bartlett* and *R. H. Feierabend*—This is the story of construction of the world's first offshore sulfur mine—largest steel structure ever erected in the ocean. It is located in 50 ft of water seven miles from the Louisiana coastline. In design of this installation, the experience of the petroleum industry in construction of offshore drilling sites was utilized. **Ref.:** (MINING ENGINEERING, **June 1960) AIME Trans., 1960, vol. 217, p. 578.**

Status of Geochemical Prospecting in the U.S.S.R. by *H. E. Hawkes*—The significance of geochemistry to Russian plans of greater mineral productivity is assuming major proportions. The author provides a résumé of their organization and progress in this field. He draws the following conclusions: geochemical prospecting in Russia and the West has evolved independently, many of the developments paralleling each other. In some cases Western methods are more advanced, in others the reverse is true. Principal difference is in scale of operations. In 1956, date of the most recent full report on geochemical prospecting activity in the Soviet Union, the Russian work in both experimental and applied fields of geochemical prospecting was probably between five and ten times the efforts of all Western nations combined. **Ref.:** (MINING ENGINEERING, **June 1960) p. 591.**

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available* **only if followed by a preprint order number.** *These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N. Y.*

Deep Sea Minerals of Economic Importance by *John L. Mero*—Manganese nodules dredged from different parts of the world's oceans averages over 20 pct Mn. Manganese in some localities may grade as high as 45 pct. Estimates indicate reserves of hundreds of billions of tons of manganese nodules available for economic mining. Preliminary calculations indicate that mining of this material is practical, both technically and economically. Estimated mining costs are between $3 and $5 per ton.

Phosphorite is another mineral occurring in great abundance on the sea floor. The material assays about 30 pct P_2O_5 and could easily make a fertilizer grade phosphate rock after calcining. Many other sediments covering the deep sea floor might serve as economic sources for many of the minerals the metals industry now uses in abundance. The attractiveness of these materials is their great abundance and low mining costs. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Rock Colors, The Basis of a New Mineral Industry by *Stuart H. Ingram*—Colored rock as applied to roofing and landscaping is treated in detail. Among the aspects considered are: a description of the "built up" type of roof and the function of the rock cover; a discussion of rock qualities and their relative values in determining rock types suitable for roofing uses; the economic position of rock roofs; comparative costs and life expectancy of various roof types; and marketing investment requirements. The preparation of granules, descriptions of operating mills, and mill circuits are covered as well as desirable qualities in the granules such as freedom from moisture and dust, importance of shape, and size range and distribution within that range in determining roof coverage. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Geological Features of Boron Mineral Deposits by *Ward C. Smith*—The leading commercial sources of borax and other boron compounds are continental sedimentary deposits, of Cenozoic age, accumulated and preserved in the arid parts of the world's Cenozoic tectonic-volcanic belts. The raw material worked at such deposits has some diversity, as follows: crystalline boraxkernite ore interlayered with shale at Kramer, Calif.; colemanite-ulexite ore in shale in California and Nevada, and in Turkey; brine in porous sodium salt layers at Searles Lake, Calif.; borax and ulexite in the surficial efflorescences and layers of desert basins in the western United States and in South America; borax in the aprons of thermal springs and in lake muds in Tibet. Substantial quantities of boron compounds also have been produced from other deposits that differ widely in mineralogy and in geologic origin and age: boric acid from active steam vents in Larerello, Italy; boracite in Permian marine salt deposits at Stassfurt, Germany; szaibelyite and hydroboracite in Cenozoic (?) replacement deposits in the Inder district, Russia; tourmaline in Precambrian gneiss, and kotoite in marble that is contact metamorphosed by Cretaceous granite in Korea. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Borax Production Processes by *Chester R. Beam*—The three major processes used for borax production are dissolving and recrystallization as used by U.S. Borax, brine evaporation followed by a crystallization step as used by American Potash, and carbonnation for sodium bicarbonate crystallization followed by chilling to crystallize borax as used by both West End and American Potash. The U.S. Borax process is designed to separate the borax from an insoluble clay while the processes used at Searles Lake are designed to separate the borax from large amounts of soluble salts occurring in the brine. All of the processes use a chilling and crystallization step for the final separation of the borax from the mother liquor. The crude borax is futher refined dissolving and recrystallizing to produce decahydrate and pentahydrate. Anhydrous borax is produced by partial drying of decahydrate followed by melting in a direct fired furnace. The molten product is then cooled, crushed, and ground. In addition to the basic products, U.S. Borax produces a variety of crude borate products directly from the ore. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Mining Methods at Boron-Past, Present, and Future by *F. M. Smith*—Boron is located 120 miles northeast of Los Angeles. Mining started in 1926 on the relatively flat lying lense shaped ore body of borax and kernite, covered by 150 to 1000 ft of overburden. Underground mining progressed, in 24 years, from hand methods to continuous miners and conveyor belt haulage. Various types of stoping—including shrinkage, room and pillar, and block caving—are used. Contract stripping on the Boron pit started in January 1956 by Isabel Construction Co. using push-loaded scrapers. Ore mining commenced in May 1957 using electric 3-yard shovels and 20-ton trucks. Stripping is still carried on by scrapers, but operated by company personnel.

In future mining plans, conveyor belt haulage for both ore and waste removal, will be used. All methods of stripping are being studied to determine the most economical method of overburden removal. World wide visits to strip mines by company personnel have indicated the bucket wheel excavator and conveyor haulage as the most economical method. However, further tests of the overburden are necessary to determine if this type of machine can successfully cut the hard overburden encountered at Boron. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Organic Boron Chemicals by *Kendrick R. Eilar*—Organic compounds of boron have been of theoretical interest to chemists for many years. Commercial interest is now beginning to develop. Compounds involving boron-to-carbon bonds and boron-to-oxygen-to-carbon bonds are derived from boric acid or from the more versatile boron halides. The principal types of reactions involved in their syntheses are illustrated. The borate esters and acylates are generally very reactive with water while the boron-carbon bonded compounds are most reactive with oxidizing agents. These characteristics can be modified substantially, however, by appropriate changes in the structure of the molecule. *AIME Southwest Metals and Minerals Conference, Los Angeles, April 1960.*

Cushenbury Limestone Quarry Operation by *John H. Lucas*—The Cushenbury Limestone Quarry is unique in one sense for a cement plant quarry in that two different types of rock are mined. One grade of rock containing a maximum of 2 pct silica is mined as flux rock for the Kaiser Steel plant in Fontana, and the remainder of the rock over 2 pct silica is mined for use in the manufacture of cement. Overburden is of such minor thickness that there is no stripping required.

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Geology of the Lakeview, Oregon, Uranium Area by *Norman V. Peterson*—Economic occurrences of uranium were discovered near Lakeview in southwestern Lake County, Ore., in 1955. As a part of a continuing uranium project the State of Oregon Department of Geology and Mineral Industries has conducted reconnaissance and semi-detailed mapping has been extended in all directions to cover an area of about 150 square miles. The Lakeview uranium area is in the southern part of the Freemont Mountains and just west of the northern part of Goose Lake Valley. The paper details the geologic structure of the area. *AIME-ASM Pacific Northwest Metals and Minerals Conference, Portland, Ore., April 1960.*

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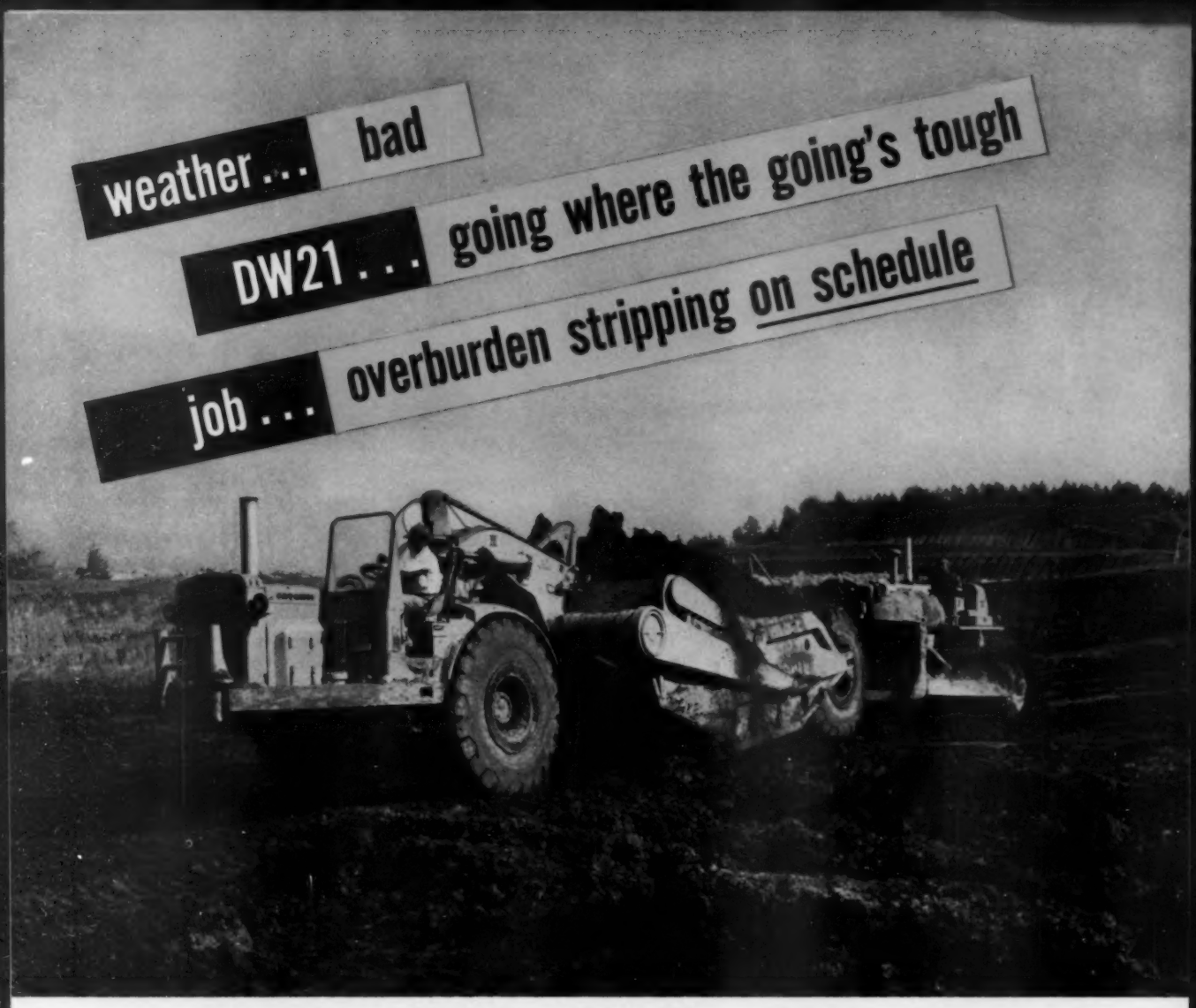

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But the job was completed on schedule. Five DW21s and 470B Scrapers moved 10,000 cu. yd. per 20-hour day. They carried 16 bank cu. yd. on a 3600′ cycle.

Here's what Superintendent Clyde Moore has to say about the DW21s: "We're a 100% Cat-equipped company. The new DW21 is the best hauler we've ever used. It's got lots of speed and traction. It goes through mud that's tough for track-type tractors."

This is the kind of performance you can expect from the new DW21G. Its 345 HP diesel delivers 12% more rimpull which provides up to 20% faster speeds than the former models over similar haul conditions. To handle this increased horsepower, the DW21 has stronger final drive gears and improved transmission shifter forks. The matching 470B LOWBOWL Scraper has greater capacity . . . 19.5 cu. yd. struck . . . 27 cu. yd. heaped. Stronger bowl, draft frame and apron result in longer service life, less maintenance.

The new DW21 is geared for today's highly competitive market. It's a high-capacity rig designed to move more dirt at a lower cost.

Pick your toughest job. Then pick up your phone and call your Caterpillar Dealer. Ask him to demonstrate the heavy-duty, profit-making DW21.

Caterpillar Tractor Co., General Offices, Peoria, Ill., U.S.A.

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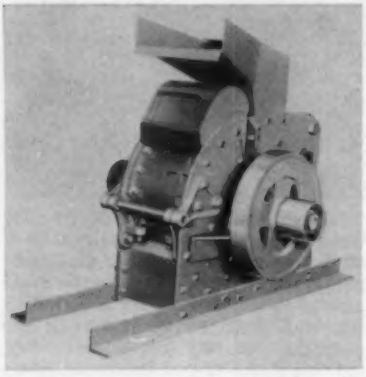
MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

Hammer Crusher

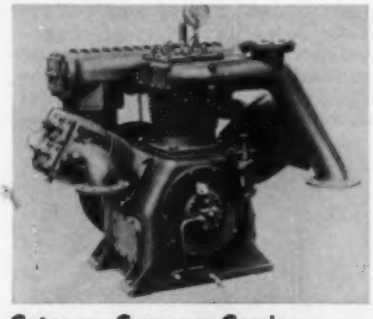
An inexpensive, economical, all-purpose pulverizer for industrial and aggregate crushing installations is offered by *Iowa Mfg. Co.* Used for pulverizing burnt lime, gypsum, limestone, etc., it is also designed



to serve as a sampling crusher in the mining industry. Long life, low maintenance, low initial cost, and low operating costs are some of the advantages of this unit, termed Cedarapids Model 20. **Circle No. 1.**

Air Compressors

The CR series of all-purpose air compressors, capable of delivering 174 to 338 cfm, is now being marketed by *Atlas Copco*. With rated working pressures up to 125 psi, the units are two-stage, single-acting, compressors featuring air-cooled cylinders and cylinder heads, and designed for heavy-duty, three-shift operation. **Circle No. 2.**



Catenary Conveyor Carrier

A true catenary suspension for conveyor belts under all load conditions has been developed by *Stephens-Adamson*. Known as Flexiroll, it features a high tensile spring steel "dead shaft" and contact of all rollers with the belt. Use of all rollers supports the belt in a natural arc which contributes to more efficient belt training and to reduced belt wear. **Circle No. 3.**

Support Lagging

An economical and versatile support lagging for use as cribbing has been offered by *Commercial Shearing and Stamping Co.* Light, fireproof, and inexpensive, the support lagging has a ribbed surface permitting interlocking when overlapped with the next lagging mat. This allows increase wall system strength and eliminates need for anchoring the mat. 11½ in. wide, the lagging is available in lengths to nine ft. **Circle No. 4.**

Escape Mask

Mine Safety Appliances Co. has announced development of an 8-lb self-contained breathing apparatus to permit rapid exit from excessively contaminated or oxygen-deficient atmospheres. The air cylinder contains 6½ cu ft of compressed air, providing protection under exertion for five min. Unit is designed for instant operation. **Circle No. 5.**

Bunker Cushions

Pneumatic bunker cushions which eliminate flow stoppages in bins and hoppers are available from *Tressler Engineering Products Division*. Utilizing the principle of positive displacement, the cushion can exert a force of 56,000 lb when inflated under pressure of 45 psig. The unit consists of a rubber diaphragm bolted to a re-inforced steel base which includes inlet port and exhaust valve. Attached to the sides of bins, each cushion measures approximately 31½x39½ in. and will inflate to an operating height of 15¾ in. **Circle No. 6.**

Torque Wrench

The 2DF-300 Torque Wrench from *Apco Mossberg* assists application of precise torque to fastener bolts on mine support timbers and maintaining of proper tension on interconnecting cables. A 3-in. diam dial mounted on side of the handle permits easy, accurate reading of torque. **Circle No. 7.**

Geophysical Survey Kit

Sharpe Instruments is marketing a portable kit containing an airborne-ground magnetometer, a ground voltameter, and an electromagnetic survey unit. This kit features exceptional compactness, portability, and ease of operation. Designed for prospecting and reconnaissance work, the entire unit may be carried on a man's back and is reported to take considerable abuse without damage to the instruments. **Circle No. 8.**

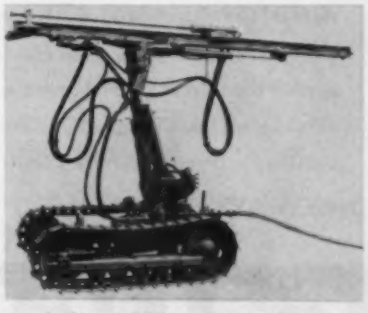
Car Shaker

A one-man-operated car shaker, capable of being mounted anywhere on a car side, is being produced by *Syntron Co.* Moved by jib crane or fork lift to desired site, it has no chains or rods to tighten and there

is no need for operator to get in, on, or under the car. The self-contained rotary vibrator, designed for light or heavy flanged car sides, produces 900 powerful vibrations per minute and operates from a 220 or 440-v, 3-phase, 60-cycle a-c supply. **Circle No. 9.**

Crawler-Mounted Drill

The G-900 Tracdril, available from *Chicago Pneumatic Tool Co.*, features hydraulic controlled drilling maneuvers—swing, lift, dump, and tilt. The unit covers a 17-ft diam 180° arc, has dual controls and a 12-hp tramming team for propulsion. Specially designed 10-in. tracks



maximize stability of unit. The machine can drill horizontal holes ranging from 25 in. above the ground level to a maximum height of 11 ft. Carriage dump adjusts 360°, increasing top-hole reach; 85° carriage swing allows drilling of vertical holes regardless of slope conditions. **Circle No. 10.**

(Continued on page 538)

for successful mineral processing . . . quality check with Geary-Jennings Sampler

Some complex mineral processes require constant checking and continuous control. Geary-Jennings Sampler provides data for these systems automatically and with the speed and accuracy demanded by modern methods of automation. Geary-Jennings Samplers have been applied to complex production systems in many industries including: metals, rock products, coal and chemicals, where it automatically applies the correct sampling principle, *all of the stream part of the time,* to either wet or dry materials. For impressive list of plants that use the Geary-Jennings Sampler and for illustrated description of the principle and mechanism of this great sampler — write or call on us.

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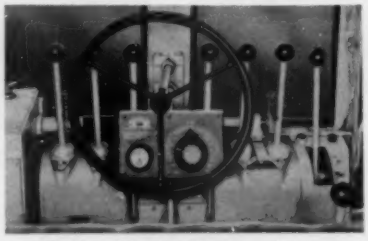
Manufacturers News

(Continued from page 537)

Automatic Blade Control

The *Preco Co.'s* Dial-A-Slope automatic blade-control is available for installation on any current model of *LeTourneau-Westinghouse* motor grader. The control relieves operator from constant adjustment of both left and right blade lift levers. The Dial-A-Slope control permits operator to concentrate on steering and



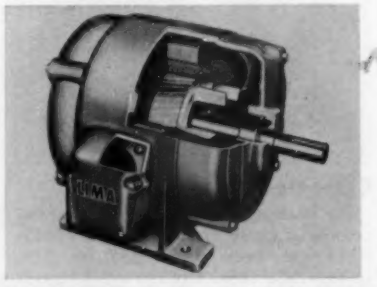
regulating his depth of cut. To put in operation, the operator sets desired degree of slope on a dial and turns a lever to select the blade end he wishes to have under automatic control. Greater accuracy savings in staking costs, and less engineering time are just a few of the advantages cited. **Circle No. 11.**

Ventilation Tubing

"MineDuct", a re-inforced spiral wire ventilation tubing from the *American Brattice Cloth Corp.*, is manufactured from Neoprene-coated cotton fabric and steel wire. The tube is flame-resistant, flexible, airtight, strong, light in weight, and retractable. Yellow in color for added visibility and safety underground, it is available on special order with an added exterior wearstrip for rough service. **Circle No. 12.**

Drip-Proof Motors

Redesigned to meet new NEMA specifications, *The Lima Electric Motor Co.'s* type RS drip-proof general purpose motors feature fully seasoned cast iron frames with integrally cast feet to assure highest degree of rigidity in mounting with-



out stator distortion. Solid die cast rotors, Mylar insulation, and dynamically balanced rotor assembly are featured. Available from 1 to 50 hp, three or two-phase, and in all standard frequencies and commercial voltages below 600v. **Circle No. 13.**

(21) SOIL GAUGE: *Soil-test Inc.* has issued a new bulletin about the Nuclear-Chicago d/M Gauge for surface moisture and density measurement of soils and similar materials. The new nuclear devices are designed for use by engineers, agronomists, scientists, and contractors. The bulletin gives complete specifications for the instruments and shows their correct use for both moisture and density tests in conjunction with soil compaction work.

(22) MOTORS: A 14-page, two-color bulletin (No. GEC-1049) has been issued by *General Electric Co.* to give selection and buying information for their Tri-Clad 55 motors, single and three phase. It includes all basic information needed by most motor users. Application chart gives types recommended for various loads and ambient conditions. Dimensions, prices, characteristics, plus performance data, modifications, and accessories are provided.

(23) DUST CONTROL EQUIPMENT: A new high energy dust and fume scrubber, the Oriclone, is described in four-page Bulletin No. W-8560, released by *The Ducon Co. Inc.* The bulletin, a comprehensive description of the unique design and operational features of the scrubber, discusses its high efficiency even in submicron particle size range, low initial cost and operating cost, small size, and its ajustable orifice for maintaining peak efficiency under varying conditions.

(24) VIBRATING MILL: A 30-in vibrating mill suitable for continuous processing of a wide range of materials is described in a new leaflet issued by *Allis-Chalmers Manufacturing Co.* Powered by two 50-hp motors, the compact mill can out-produce a tumbling mill 15 to 30 times per unit volume. Initial cost of the mill is at least one-third lower than any other machine of comparable capacity.

FREE LITERATURE

(25) MOTOR SCRAPER: A new four-page full color fold-out, MS-1376, briefly describes the operating features of the recently introduced 30 cu yd *Allis-Chalmers* TS-360 motor scraper. The literature points out the advantages of the scraper's all-hydraulic operation and its "Kontork" differential.

(26) URANIUM FLOWSHEET: A 12-page technical review of uranium concentration at the *Susquehanna-Western Inc.* mill at Riverton, Wyo., has been recently released by *Denver Equipment Co.* The article covers both the acid and carbonate circuits in the mill. The flow sheet is illustrated and described throughout the various stages of operation, and details of the acid section and solvent extraction recovery system are given.

(27) TRACTORS: Features of the new D6 tractor are described in a 12-page, two-color booklet published by *Caterpillar Tractor Co.* Among items discussed are a new diesel engine rated at 93 flywheel horsepower with 25% more lugging ability, a new dry-type air cleaner, the exclusive "Cat" oil clutch, and lifetime lubricated track rollers and idlers. Also listed are specifications, plus attachments and tools for logging and other applications.

(28) VENTILATION TUBING: The *Bemis Bros. Bag Co.* has issued an interesting 12-page booklet describing Flexipipe mine and tunnel ventilation tubing. Well illustrated with diagrams and tables, grades of tubing, accessories, and suspension methods are discussed. Photos of actual installations are included.

(29) ACID-PROOF SUMP PUMP: A four-page brochure from *The Gallagher Co.* describes seven acid-proof sump pumps in sizes 1¼ in., 1½ in., 2½ in., 4 in., and 6 in. Photograph and specifications of each pump are included with its range of application.

(30) DUST COLLECTOR: *American-Standard Industrial Division* has issued a six-page, two-color bulletin, describing its new Series 345 dust collector line. Highlight of Bulletin No. 1928 is a pair of easy-to-use nomograms, one for collector selection, the other for efficiency determination. Simple directions for using the nomograms are presented and related to an example problem.

(31) ENDLESS BELT TYPE FILTER: *Komline-Sanderson Engineering Corp.* has published a four-page, two-color brochure, No. KSI-4, describing the new Flexibelt filter. This filter is a continuous vacuum drum type filter designed to allow continuous take-off, wash, and return on endless filter cloth, and to overcome or minimize the limitations normally encountered in rotary vacuum filtration.

(32) INDUSTRIAL TRUCKS: A new 12-page brochure from *Lead Industries* facilitates rapid estimation of unit costs incurred by industrial trucks. Nomographs and alignment charts show costs of depreciation, maintenance, and operating costs accurately for gasoline-powered and battery-powered trucks. It is reported that only basic data on plant operation is required to arrive at a reliable cost estimate for each mentioned factor.

(33) TRACK CLEANER: The Canton track cleaner is the subject of an eight-page brochure from *The American Mine Door Co.* Description and specifications of the machine plus photos of actual use in mines are provided.

mail this post card for more information

6

Mining Engineering 29 West 39th St. New York 18, N. Y.

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61	62	63	64						

Students should write direct to manufacturer.

(34) TRACTOR LOADER: *Allis-Chalmers Mfg. Co.* has issued two bulletins featuring the TL-14 tractor loader and the TL-12 tractor loader. Bulletin MS-1373 contains information on the two transmissions available for the 83 hp TL-14. A bucket selection chart and complete specifications are also included. Bulletin MS-1386 is a specification sheet of the recently-introduced TL-12 tractor loader.

(35) ENGINES: "Judging Engine Quality", a 28-page illustrated handbook published by the *Caterpillar Tractor Co.*, contains useful information for everyone involved with the purchase of engines. It discusses in detail the factors involved with 1) excellence of design, material, and workmanship; 2) reliability; 3) cost of operation, 4) parts and service availability; and 5) trade-in or resale value.

(36) MATERIAL-LEVEL INDICATOR: Accurate, automatic level control of pulverized, fine, crushed, or granular material in bin or silo is the subject of a new bulletin (I-5-C) published by *Fuller Co.* Illustrations and descriptions of the features and functions of two types of material-level indicators for general purpose or for hazardous dust conditions are supplied.

(37) CONVEYOR-SCALE SYSTEMS: A four-page bulletin on the use of conveyor-scale systems for flow-rate control and total through-put measurement of bulk materials has been published by *Weighing & Control Components Inc.* Bulletin 60 discusses the use of W-C conveyor-scale systems in conjunction with flat-bed or trough-type conveyor line systems of fixed or varible speed, to provide in-motion weight measurement. System operation is explained and illustrated with pictorial diagrams. Application and performance data is given on all of the unitized system components.

(38) FLOTATION REAGENT CATALOGUE: If flotation is your business, request "Flotation Reagents" from *American Cyanamid Co.* This new 48-page bulletin discusses in detail promoters or collectors, frothers, modifying agents, activating and depressing agents, flocculants, reagent feeders, plus reagent practice on metallic ores and the flotation of metallic oxides and nonmetallic minerals. A selected flotation bibliography and a series of very helpful tables pertaining to functions of various reagents, usages of modifying agents, promoters, and frothers are included.

(39) GLASS-BAG FILTERS: Bulletin No. 806 recently issued by *Dracco Division* of *Fuller Co.* tells how to lick one of the toughest air pollution problems in industry—that of hot, corrosive dust and fumes. Three installations in the cement and metallurgical industries are described by way of illustration. In addition, the bulletin discusses methods of cleaning glass fabric bags so as not to injure the fiber.

(40) WELDING EQUIPMENT: Catalog 2350 issued by *Air Reduction Sales Co.* covers their complete line of welding equipment both manual and automatic. The catalog has been thoroughly revised to incorporate all recent equipment added to their line, including the AH60-B Aircomatic manual gun and two Aircomatic machine heads for production line welding.

(41) TRACTOR SHOVELS: The two largest capacity Michigan tractor shovels, Models 275A and 375A, are the subject of Bulletin TS2500 issued by *Clark Equipment Co.* Complete specifications for both machines are given with additional information and illustrations on the application of the tractor shovels to heavy duty and high production projects.

(42) IMPACT BREAKERS: A new 8-page, two-color brochure, Bulletin No. 60-A describes the full line of heavy-duty, dual-rotor impact breakers manufactured by *Kennedy Van Saun Manufacturing & Engineering Corp.* These machines are built to handle non-abrasive quarry rock and similar materials and to produce a high proportion of cubical product at high reduction rates and low cost. These breakers are used for both primary and secondary crushing and as both stationary and portable units.

(43) PERFORATED METAL: Complete specification of heavy-gauge perforated metal is outlined in a 40-page brochure, No. 8159, from *Cross Perforated Metals* of *National-Standard Co.* The data covers applications of perforated metal as screens, strainers, dryers, separators, supports, guards, ventilators, and drains for the mining industry. Pattern specification, dimensions, unit weights, calculation of open area, materials selection, fastening methods, and equivalence tables relating wire cloth to square, round, and Cross Hexcreen patterns are included.

(44) POWER SHOVEL: Recently issued by the *Thew Shovel Co.* is a 12-page bulletin on Lorain's 2 yd 820A power shovel. Also available as a crane, dragline, clamshell, and hoe, it features a 10-yr warranty on its "Shear-Ball" connection. The booklet gives details of design and construction including air controls.

(45) ALUMINUM WHEELS: *Aluminum Company of America* has issued a six-page brochure entitled "Weigh the Facts" explaining the advantages of aluminum over steel in truck wheels. Among these advantages are extra payload, longer tire life, and reduced maintenance costs. These and other profitable benefits are supported by tabular and case-history data.

(46) ECCENTRIC VALVES: *Dezurik Corp.* has published an eight-page bulletin describing the features, pressure ratings, dimensions, and accessories of eccentric valves. For mining and ore dressing, the valves can be supplied with rubber lining to effectively resist the abrasive power of ore slurries.

(47) RUST REMOVER: *Rusticide Products Co.* has brought out a new folder describing the uses of Rust-I-Cide in removing rust and conditioning metal surfaces. Its applications include cleaning of equipment and other metal products, removing discolorations, preparing new metal for painting. Prices and directions for use are included.

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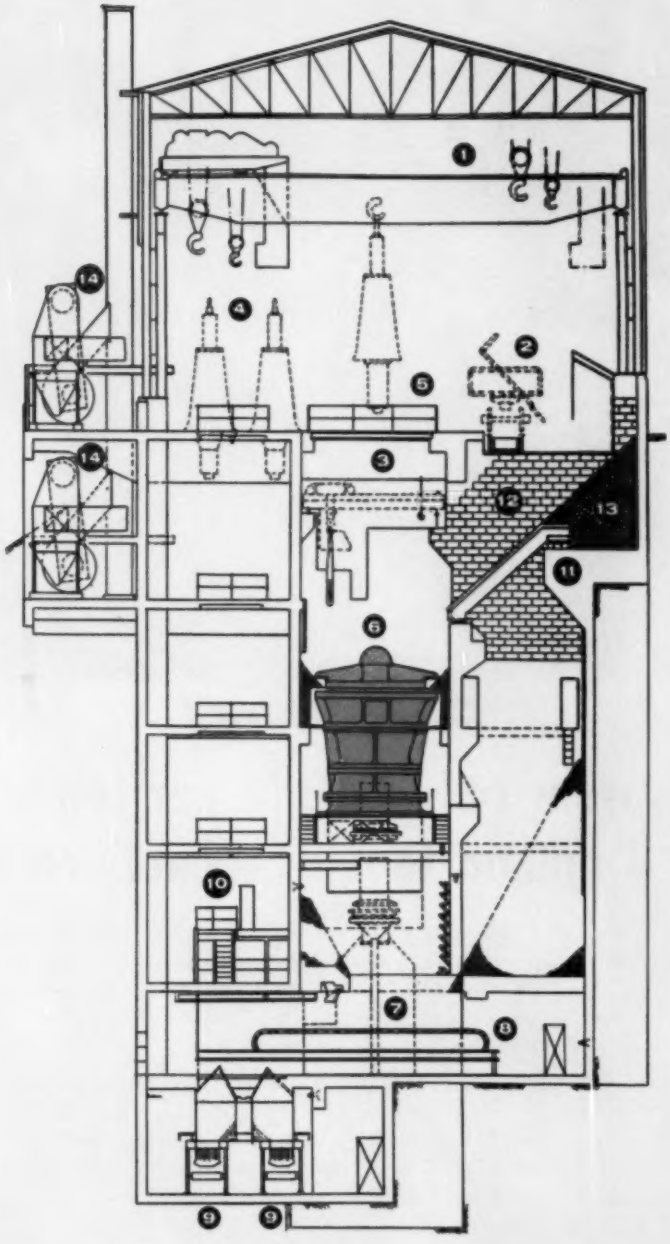

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world's largest manufacturer of 60" gyratory crushers designed and built this giant for installation in Peru.

The Southern Peru Copper Corporation called on Traylor-made ECONOMY, EFFICIENCY, AND CAPACITY to handle the tremendous crushing workload at its new plant in Toquepala, Peru.

Drawing shows Traylor 60" gyratory crusher operation:

1. 100-ton crane with 25-ton auxiliary hook and operator's cab
2. 43-cu. yd. side-dump mine car
3. 20-ton crane with rock hook
4. Mantle storage
5. 18 x 22-ft. removable hatch
6. 60-in. Traylor gyratory primary crusher
7. Hydraulic hoist, 14-ft. lift, 25-ton capacity
8. Two 72-in. pan feeders
9. Two 54-in. chain-belt conveyors
10. Electrical control panel
11. 8-in. grizzly
12. 2-in. plate liners
13. Dead-bed areas
14. Air filter dust removal unit

Other Traylor Crushers made for primary, secondary or fine reductions. Write today outlining your crushing requirements and let Traylor's engineers make recommendations . . . or ask for Bulletin No. 1126.

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TCA-9

Good for long grind. Ni-Hard liners save labor, cut maintenance and grinding costs by providing the utmost in tonnage-life.

Results obtained in this grinding aisle at Inco-Canada show the type of economies you can count on for your own mills.

Ni-Hard shell liners wear only .018 lb per ton grinding more than 3 million tons of nickel ore

This high tonnage-life demonstrates the outstanding performance of Ni-Hard* nickel-chromium white iron shell liners in the plant shown above.

In service since 1951, two sets of Ni-Hard lifter bar liners were removed recently from the rod mills here at Inco's Creighton concentrator in Canada.

Used in large mill

The Ni-Hard shell liners served in 10′8″ x 13′ mills grinding highly abrasive nickel ores with 3″ and 3½″ rods. Mills ran at 60% of critical speed. At the discharge, solids in the slurry ran 70%. Total life in the #1 mill was 3,430,000 tons of ore; in #4 mill, 3,266,000 tons. The liners for each mill originally weighed 60,912 lbs.

This example of Ni-Hard shell liner service is a severe one . . . nickel ores are among the toughest. But the record of Ni-Hard liners in such service points up what this material can do in all grinding operations.

For answers to your further questions about Ni-Hard liners, just pick up the phone and call your nearby Ni-Hard producer. Or write Inco directly. We'll send you a list of authorized producers and a copy of the useful booklet, "Engineering Properties and Applications of Ni-Hard."

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THE INTERNATIONAL NICKEL COMPANY, INC.

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NI-HARD

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

MINING engineering REPORTER

Fria Complex Ships First Alumina

The first alumina for export from the $150-million Fria complex left the port of Conakry in the Republic of Guinea in the first week of May. Bauxite reserves of the project total more than 200 million long tons; present alumina output is 550 tpd, but will be increased as needed by the six international companies holding stock in the complex.

Inco Schedules New Open Pit

The Clarabelle, a new open pit nickel mine in the Sudbury district of Ontario will be developed by International Nickel Co. of Canada Ltd. Output, scheduled to begin late in 1961, will bring no increase in Inco's overall production but is intended to supplant tonnages from other mines. The orebody outcrops in the area of Clarabelle and Lady Lakes, southwest of Inco's Murray mine.

Herculaneum Smelter Increase Planned

St. Joseph Lead Co. announced at its annual meeting that capacity of the Herculaneum, Mo., lead smelter would be increased from the present 100,000 tons annually to 150,000 tons by the end of 1962. A company officer predicted use of lead would increase by 5 pct and use of zinc by 10 pct this year, with a possible upstep in prices for both metals.

Zinc Mining Agreement

Tri-State Zinc, Inc. and American Zinc, Lead & Smelting Co. have signed a pact calling for Tri-State to mine American Zinc-controlled properties in the area of New Market, Tenn. Tri-State, wholly owned by a subsidiary of Consolidated Gold Fields of South Africa Ltd., will invest some $3 million to $4 million to bring in annual zinc concentrate production of 35,000 to 40,000 tons. Estimated reserves of the area total about a million tons of concentrate.

Bunker Hill Workers Strike in Idaho

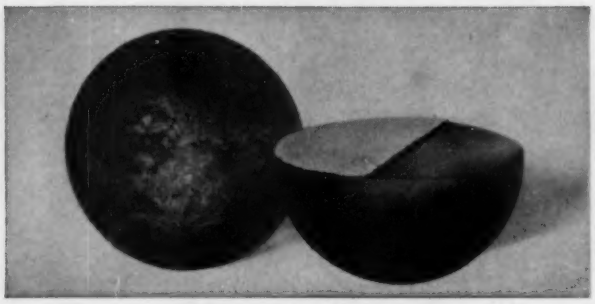
Mine and smelting workers at the Kellogg, Idaho, lead-zinc plants of Bunker Hill Co. went on strike for a pay boost and benefits totalling 30¢ per hr, including an 8¢ wage increase retroactive to July 1. The company has offered 15¢ and no retroactive pay hike.

Small Lead-Zinc Mine Subsidy Bill

Financial aid to small lead-zinc producers is the aim of new legislation just approved by the House Interior Committee. The plan calls for payment of up to 17¢ per lb for lead and 14.5¢ for zinc, with an annual limit on production of 2000 tons. For producers to qualify for payments, the bill would require that they have been in operation for at least a portion of the last seven years.

Steep Rock Project to Cost $66 Million

Caland Ore Co. Ltd., subsidiary of Inland Steel Co., dedicated its iron ore mining project at Steep Rock Lake early in May. J. L. Block, chairman of Inland, announced development expenditures would total some $66 million upon completion. Dredging has uncovered a portion of the orebody, permitting start-up of open pit work. Underground development is expected to begin in 1963.



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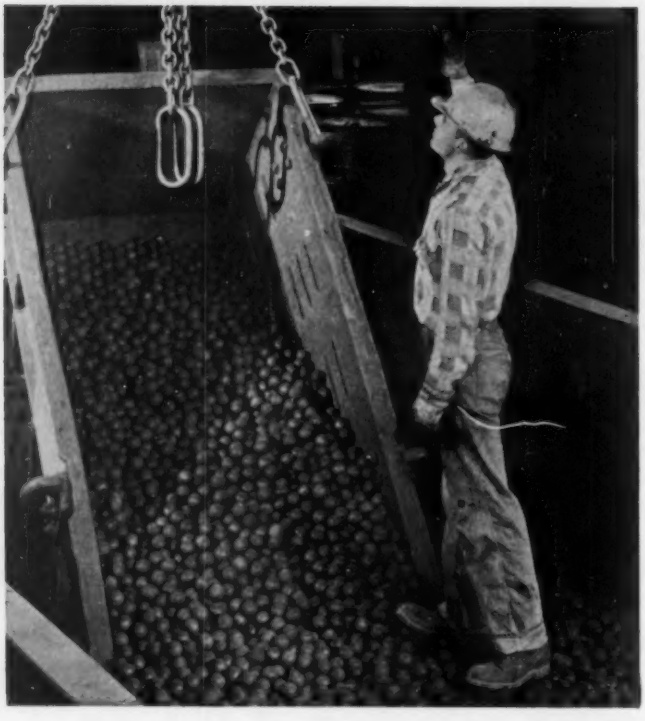
hardness at the surface

. . . toughness to the core



Moly-Cop Balls will give you better grinding at lower cost. What's behind this fine performance? Hardness, toughness and uniformity. Hardness to fight wear. Toughness to resist spalling and breaking. And uniformity of fine grain structure right to the core. Result: Moly-Cops keep their spherical shape longer. Fewer chargings. Less down time. Money saved.

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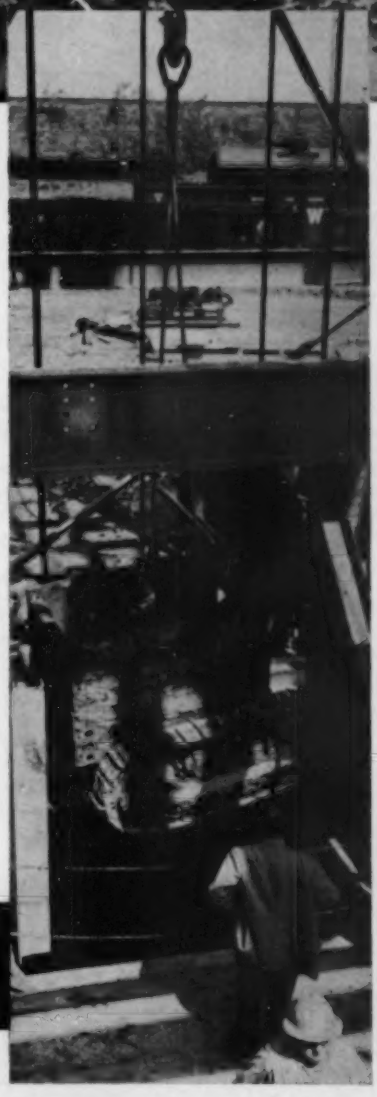

"18' IN ROCK SHAFTS SUNK AND CONCRETED 800 FEET IN 85 WORKING DAYS WITH EIMCO 630 IN CLEVELAND, OHIO"

Report on Joint Venture by Frazier-Davis Construction Co. and Hunkin-Conkey Construction Company.

"An Eimco 630 Excavator is loading an average excavation progress of 15 feet per working day in 18 foot diameter shafts in rock. Average mucking time is 6.25 minutes per three cubic yard bucket or 28.8 cubic yards per hour. One operator has averaged as high as 30.9 cubic yards per hour for a two week period. Part of this mucking operation is accomplished inside the concrete forms with a working diameter of only 15' 4". Average shaft progress is 9.41 feet per day, including concrete lining and utilities."

So reports A. Leavitt Crowell, Project Manager for Frazier-Davis Construction Company on two vertical shafts for International Salt Company at Whiskey Island, Cleveland, Ohio.

Shafts will go about 1,900 feet and with two Eimco 630's on the job, you may be sure the job will be completed fast and economically. Proven in service around the World, the Eimco 630 is reliable, tough and efficient.

Get all the facts! Contact the Eimco sales office or dealer nearest you, or write The Eimco Corporation, P. O. Box 300, Salt Lake City 10, Utah, U.S.A.

"ADVANCED ENGINEERING AND QUALITY CRAFTSMANSHIP SINCE 1884"

THE EIMCO CORPORATION

MINING EQUIPMENT DIVISION

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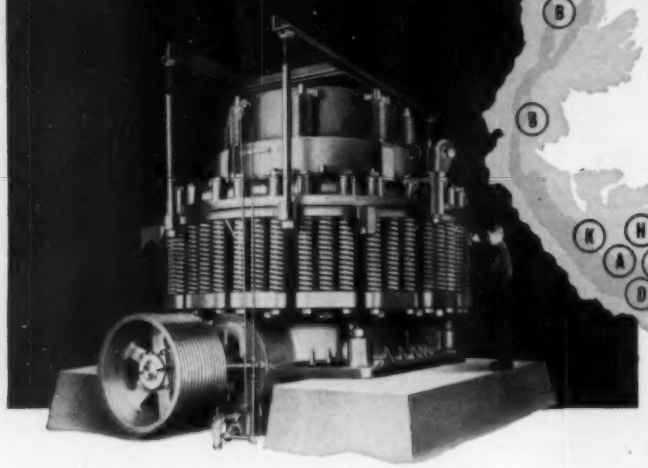
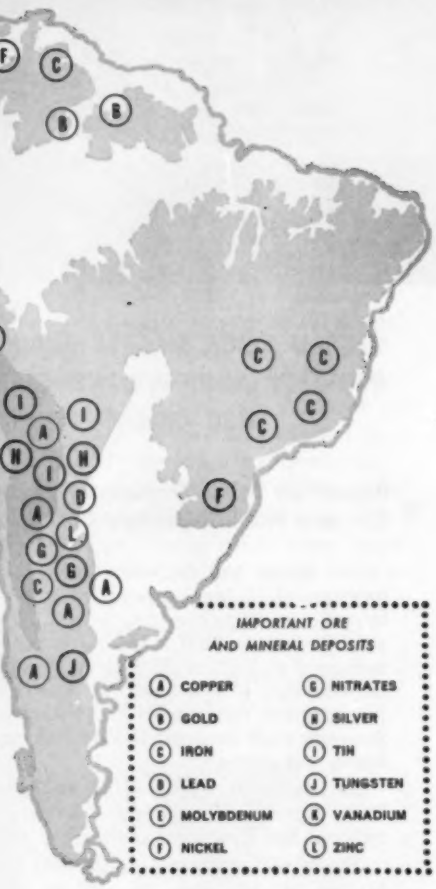
SYMONS® CONE CRUSHERS

play important role in processing ores and minerals in *South America*





In all of the important ore and mineral operations around the world . . . Symons Cone Crushers have consistently maintained a preferred position by efficiently processing large tonnages of finely crushed product at low cost.

In South America, scores of Symons Cones are used by leading producers of many of the country's ores and industrial minerals. Included in this group are the well known nitrates and copper ore of Chile . . . the tungsten, copper and vanadium of Peru . . . Bolivia's tin, second in world production . . . as well as the great mineral reserves of Brazil.

The use of Symons Cone Crushers in South America serves as another good example of the way these efficient reduction machines serve the mining and mineral processing industries of the world.

NORDBERG MFG. CO., Milwaukee 1, Wisconsin

SYMONS CONE CRUSHERS
. . . The machines that revolutionized crushing practice . . . are built in a wide range of sizes, for capacities to over 900 tons per hour. Write for descriptive literature.

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HOW Rock-Ribbed Payhauler® GIVES YOU new load-speeding capacity!

Of all rear-dumps in their size classes, only the International 65 and 95 Payhauler models give you the weight-shedding, strength-multiplying, rock-ribbed corrugated bodies! You trade 2½ tons of power-wasting dead weight for 3 bonus tons of capacity in the new 95 Payhauler!

Only the 65 and 95 Payhauler models have the power "plus" of the direct-start, high-torque, 4-cycle 6-cylinder International "817" Diesel engine! The "95" is powered by the 375-hp DT-817 turbocharged Diesel; the "65" has the same basic, high-output power plant: the naturally-aspirated 250-hp D-817!

Choose the "95" with power-shift torque-converter, or 9-speed air-shift transmission. The "65" comes with 10-speed constant-mesh transmission. Both models have the load-speeding safety of reserve-area braking and "one-hand," road-holding power steering! Above, it's the "65" shown storming up a 16% grade with 19-ton payload. Compare how Payhauler grade-ability speeds the cycle over other haulers!

In minimum shovel time you heap-load the big-target Payhauler body. Rugged corrugations absorb rock-shock—give high resistance to wear and distortion from abrasion and impact! Torque - cushioning planetary-type axles let you apply full power to start and haul full loads!

Add up the capacity-boosting advantages of Payhauler power-to-payload *punch*—super-speedy Payhauler loading, hauling and dumping. See how either the 19-ton "65" or 27-ton "95" can give you gear-faster climb-outs—and haul up to 14% faster than other rear-dumps! See your International Construction Equipment Distributor for a demonstration!

Get 11-second Payhauler dumping with exclusive, action-speeding inverted hoist design! Simple, easy-to-operate up-and-down snubbing control prevents machine-punishing impact! Fast reverse, up to 7.1 mph., speeds spotting to dump or load!

Here's your 76-page cost and production estimating book—newest, most authentic and complete guide for estimating material-moving costs—and for selecting equipment combinations for top profits, anywhere! Yours for the asking from your International Construction Equipment Distributor!

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International Harvester Co.,
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A COMPLETE POWER PACKAGE

More proof that...

AMSCO HELPS YOU MOVE MORE TONS PER DOLLAR

How a large contractor and a crusher manufacturer have cut downtime and increased service life with AMSCO equipment

AT MT. VERNON CONTRACTING CORP.

DAILY "TOOTH REPAIR" ELIMINATED BY SWITCHING TO AMSCO 2-PART TEETH

Mount Vernon Contracting Corp. is a large general contractor doing work throughout the middle Atlantic states. Its present contract is for road construction on the Cross Westchester Expressway, linking the New York State and New England Thruways.

The firm's four power shovels and two backhoes on this job are equipped with Amsco dippers or dipper parts and Amsco Simplex* 2-Part Teeth. Reason: competitive teeth previously used required daily welding build-up to maintain their points. Now, since switching to the Amsco Simplex, teeth are changed only about once a week. And change-over is *only a 5-minute job!*

With shovels operating 8 hours a day, 5 days a week, this is a mighty important advantage for Mt. Vernon. No wonder they say—"These Simplex teeth really stand up in service, especially in rock, and save us a lot of downtime."

*Patent No. 2,904,908

AT HIGHWAY MACHINERY COMPANY

AMSCO CRUSHER ROLLS HANDLE 50,000 YDS. BETWEEN BUILD-UPS

Carroll Hicken (left) owner of Highway Machinery Company, Waukesha, Wisconsin, is a long-time user of Amsco equipment. His firm designs and manufactures self-propelled machines for crushing road material, both gravel and stone. All of their machines are rented out or sold to contractors, with maintenance and service handled by Highway Machinery.

For years, the company has used Amsco Manganese Steel Crusher Rolls exclusively. Amsco Manganese welding rods and bars are also used for build-up. On a typical rental machine, pictured at right, the Amsco rolls had *crushed over 50,000 yds. since their last build-up* six months before.

Mr. Hicken says that with Amsco Manganese rods he can multiply the life of a roll by 5 to 10 times. He adds—"They have proven very fine, and we're getting more yardage than with any rods we formerly used."

AMSCO

AMERICAN Brake Shoe COMPANY

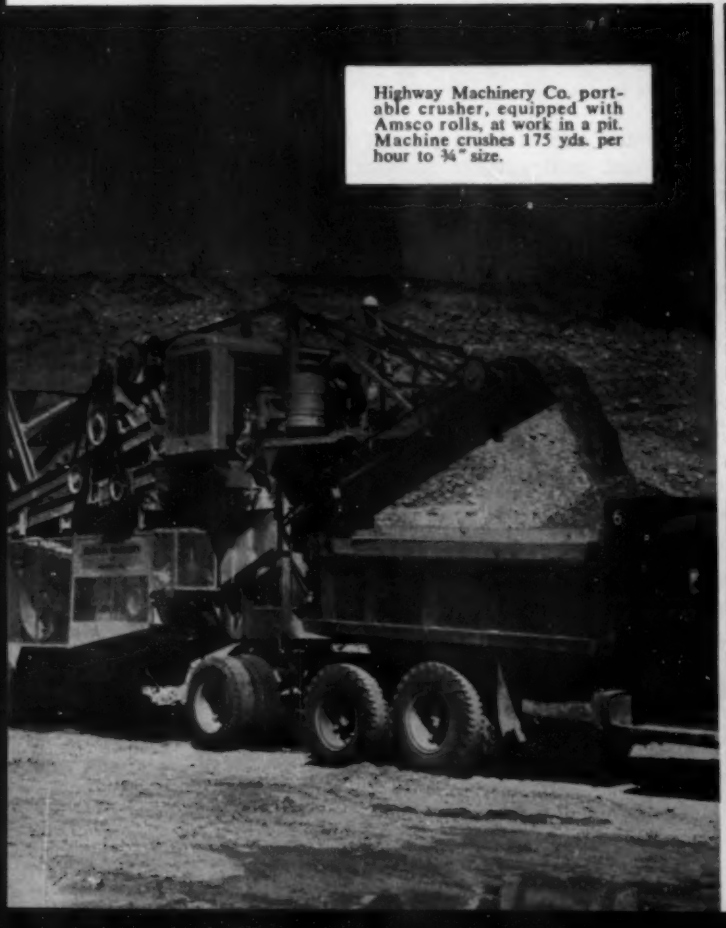
American Manganese Steel Division • Chicago Heights, Ill.

Other plants in: Denver • Los Angeles • New Castle, Dela. • Oakland, California • St. Louis
In Canada: Joliette Steel and Manitoba Steel Foundry Divisions
Welding products distributed by Canadian Liquid Air Co., Ltd.

Northwest shovel, equipped with Amsco Dipper and Simplex 2-Part Teeth, at work on Cross Westchester Expressway project.

Shovel operator, Walter Reich, inspecting Amsco Simplex 2-Part Teeth used on Mt. Vernon Contracting Corp. shovel.

Highway Machinery Co. portable crusher, equipped with Amsco rolls, at work in a pit. Machine crushes 175 yds. per hour to ¾" size.



Amsco 25 x 24 manganese steel crusher rolls, of type used in portable crusher at left.

Welder demonstrating how Amsco Manganese rods are used for build-up on rolls.

Here's proof Coromant rope-thread bits and steels
SAVE TIME AND MONEY

"Up to double the footage between sharpenings!"
"Premature rod breakage is almost non-existent!"
"40% more usable life—more resharpenings!"
"Bit and rod life are well above average!"
"Uncouple by hand all the time!"
"More rigid—drills straighter holes!"*

**Names of men quoted available on request*

The comments above are actual quotes from project managers, job superintendents, and drill superintendents who have tested new Coromant rope-thread bits and steels. They've learned, on-the-job, the benefits they—and you—can expect!

For example: The new rope-thread (only two turns per inch) holds tight in use, yet permits hand uncoupling. Reports show that the time saved results in more footage drilled per shift. Bit footage is well above average too, with less loss of carbide inserts. Prime quality ore plus nickel-chrome alloy permits cold-rolling from billets for greater strength, life and rigidity. And only with Coromant rope-thread steels can you re-thread without heat treating, too. Do it yourself, or at any nearby machine shop.

Want to know more? There's no obligation on your part, but we'll be glad to help where we can. Just call your nearest Atlas Copco Office, or write to us at Dept. ME-7.

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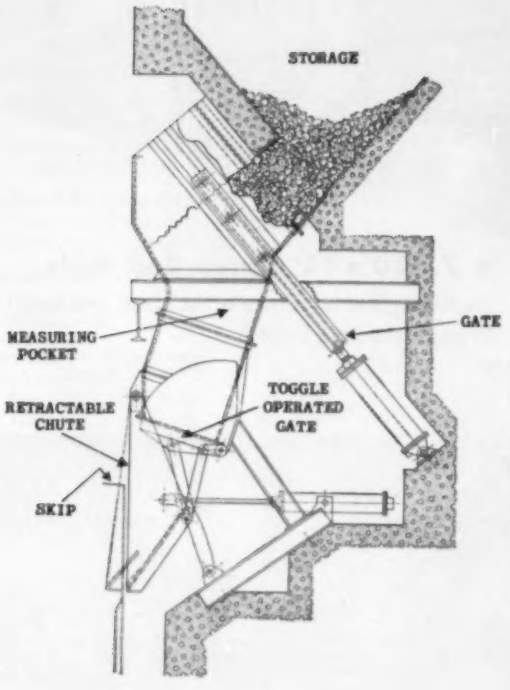
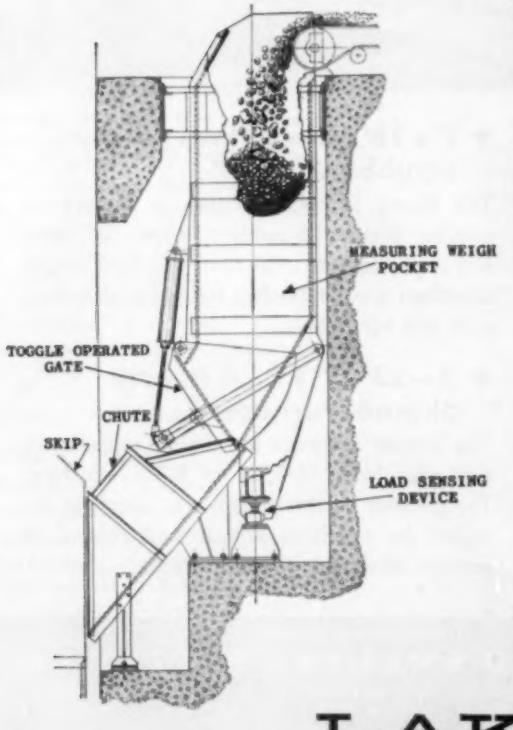
Automatic Skip Loaders





Patents Pending

NOW USED FOR HARD ROCK MINING IN MULTILEVEL OPERATIONS

MEASURED BY VOLUME SKIP LOADER

Upper cut-off gate is open, material from a storage bin above flows into the measuring pocket of skip loader. After a set time, the undercut type gate pushes up through the material. Any larger chunks above the gate will not impede the action of the gate . . . they will be floated to the top of the material flow line, which is governed by the angle of repose of the material.

The discharge gate between the measuring pocket and the skip is toggle operated for better flow and tight sealing when closed. Also, it conserves air required to operate the toggle gate. The weight of ore to be discharged actually aids in the opening of the gate once the linkage is past the center. Therefore, smaller cylinders can be utilized. Flow control with cam operated valves can be included so that gate action is smooth and operating impacts are virtually eliminated.

MEASUREMENT BY WEIGHT SKIP LOADER

This loader does not require the cutting off of load after material flow from the upper bins to the measuring pocket has stopped. A load sensing device causes the gate to close when the desired weight of load has been discharged into the measuring pocket.

This type of loader can be used in conjunction with other types of pocket feeding . . . conveyors, pan feeders, drum feeders or reciprocating plate feeders. When used with one of these feeders, the signal from the load sensing device shuts off a feeding mechanism when the measuring pocket has received the desired weight of material.

The automatic controls of both loading systems described above can be tied in with automatic hoist control to provide for a completely automated material hoisting system. In multilevel operation the complete system is actuated by one push button at the operating level. No other level can take over command of the skips without their being released at the level from which they have been operating. During operation from a given level, the loaders at other levels are rendered inoperative through interlevel interlocking control.

Lake Shore manufactures other loaders than those shown and can match the proper automatic loaders to your specific conditions.

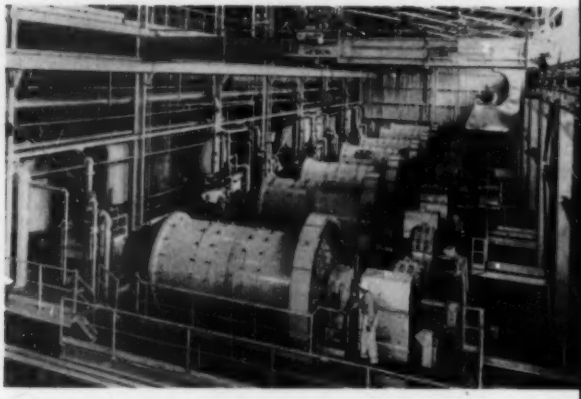
LAKE SHORE, Inc.

IRON MOUNTAIN 1, MICHIGAN

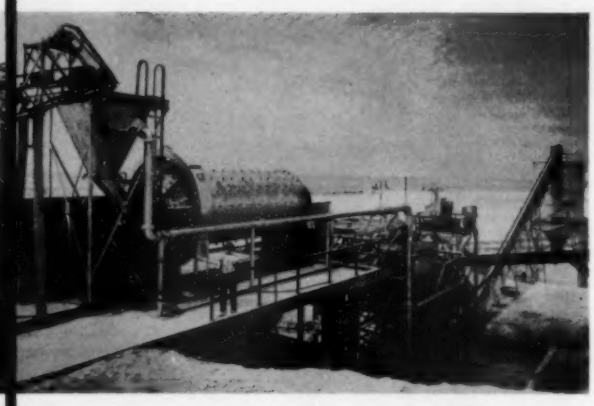
grinding
washing
drying

at Southern Peru Copper Corporation

• 7—10′x14′ Marcy Rod Mills.
The Marcy Rod Mills take a 1¼" feed, grinding to approximately 8-mesh.



• 7—8′x13′ Marcy Ball Mills.
The Marcy Ball Mills are regrinding concentrates, with feed 55% minus 325 mesh, grinding to 85% minus 325 mesh.



• 7′x16′ Marcy Heavy Duty Scrubber.
The Marcy Scrubber washes a mixture of coquina shells and pebbles; minus 10" feed. Marcy principle of small diameter, long length scrubbers gives maximum scrubbing efficiency with less horsepower.

• 3—23′-6" I.D., 4 Hearth Skinner Furnaces.
The Skinner Furnaces are drying copper concentrates from 14-15% to 6-7% moisture. The oil-fired burner system was specially designed for precision temperature control to prevent oxidation of concentrates.

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MINING engineering **DRIFT**

SME'S NEW PUBLICATION POLICY

During the 1960 AIME Annual Meeting the Board of Directors of the Society of Mining Engineers devoted much of its day-long session to discussion of a report from the SME Editorial Board and of publication policy in general. Both by specific action and by reaffirming earlier actions the Board outlined a three-fold publication program to best meet the present needs of the Society within the framework of available financing. As one step in this program MINING ENGINEERING will no longer carry Transactions papers.

Preprints: All Annual Meeting papers will continue to be preprinted and made available during the balance of the year. (This service is available for other meetings, and papers of the last two AIME-ASME Joint Solid Fuels Conferences have been preprinted.)

Monthly Journal: MINING ENGINEERING will devote a greater percentage of its pages to material of broad interest to members since it will no longer carry Transactions papers as part of its content.

Annual Volume: The Transactions papers recommended for publication by the various committees will be published in a yearly Transactions Volume only. The publication date for this volume will be at the end of the year, rather than in the spring of the following year.

The specific Board actions which affect Transactions and MINING ENGINEERING were these:

1. Voted: To eliminate Transactions papers from MINING ENGINEERING magazine beginning with the earliest issue feasible.
2. Voted: To publish papers accepted for Transactions in a single volume to be issued at the end of the year. This volume to include all current accepted technical papers.

Additional actions directed that the space made available in MINING ENGINEERING through the change in handling Transactions be used to provide greater content of general interest material. Material is to be obtained on a request basis by the Editorial Director and staff edited. The Editorial Board is to be kept informed of the future editorial program. Further, the date of publication is to be moved to the beginning of the month.

Price and size of the first Transactions volume under this program will be determined in June, and the July issue will carry a report of these actions.

CATERPILLAR ANNOUNCES 2 NEW

NEW 150 HP 977H WITH 2½ CU. YD. BUCKET

Travel speeds: Forward—Low: 2.0 MPH 1st; 3.6 MPH 2nd. High: 2.5 MPH 1st; 4.7 MPH 2nd. Reverse speeds 25% faster than forward.

NEW 100 HP 955H WITH 1¾ CU. YD. BUCKET

Travel speeds: Forward—Low: 2.1 MPH 1st; 3.9 MPH 2nd. High: 2.7 MPH 1st; 4.9 MPH 2nd. Reverse speeds 25% faster than forward.

TRAXCAVATORS

with Power Shift Transmission and Live Action Hydraulics

977 SERIES H
955 SERIES H

all new for new high production

There is a way to beat higher costs—and that's with increased production. For tractor-loader jobs, here's your answer in the new Series H Cat 977 and 955 Traxcavators. Designed to set a production pace far faster than the models they replace (and other makes of comparable size), they're milestones in tractor-loader progress. With power shift transmission and Live Action Hydraulics, they're the loaders *that never stop.*

There may be machines in your line-up that are no longer paying their way—or not earning *all* the profits they should. A comparison of your existing loaders with the new Series H Traxcavators could easily prove these new machines would increase your output and profits far more than you imagine. Get the facts from your Caterpillar Dealer. Ask for a demonstration, too. See for yourself how they set a new production pace on the toughest kind of job.

Caterpillar Tractor Co., General Offices, Peoria, Ill., U. S. A.

CATERPILLAR

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TRAXCAVATORS ARE MAKING OTHER LOADERS OBSOLETE

NEW HIGH PRODUCTION FEATURES SPEED LOADING, LIFTING, HAULING, DUMPING . . . THE FULL CYCLE

NEW POWER SHIFT TRANSMISSION

One lever—that's right, one lever gives split-second changes in speed or direction to slash cycle times and increase operator efficiency.

NEW LIVE ACTION HYDRAULICS

Another Caterpillar development! Live Action Hydraulics provide faster lifting speed and greater lifting capacity without robbing power from the tracks. The 977H Traxcavator packs 41% more hydraulic lifting power—the 955H, 23% more than former models.

MORE HORSEPOWER WITH NEW CAT TURBOCHARGED ENGINES

Up 50% on the 977H—its new Cat D333 Engine develops 150 HP at the flywheel. Up 43% on the 955H with a new Cat D330 Engine that develops 100 flywheel HP.

NEW INCREASED BUCKET CAPACITY

An 11% increase on the new 977H with new 2½ cu. yd. bucket—and a 16.6% increase on the 955H with new 1¾ cu. yd. bucket. Complete redesign of engine, power train and chassis provides new machine balance to handle the heavier loads.

NEW HEAVY-DUTY UNDERCARRIAGE

Many new features, including larger, stronger track components that also increase stability . . . lifetime lubricated rollers with patented floating ring seals need no servicing . . . and track guiding guards welded to the roller frame for positive track alignment. The 955 Series H Traxcavator also features a new 6-roller track frame and hydraulic track adjusters, both standard equipment.

MORE HIGH PRODUCTION FEATURES

A new, two-cylinder gasoline starting engine for positive starts in any weather . . . and a new dry-type air cleaner that removes at least 99.8% of all dirt from intake air in the worst dust conditions, cuts maintenance time as much as 75%. Retained features include 40° bucket tilt back . . . automatic bucket positioners and kick out . . . 3-grouser track shoes.

QUICK-CHANGE ATTACHMENTS

Bar none, Traxcavators are the most versatile machines you can use. With attachments, you can always keep them working—and working profitably. Attachments available for the new 977 and 955 include the Side Dump Bucket, Rock Bucket, Quarry Bucket, Bulldozer, Ripper and Log and Lumber Forks.

Never before drill steel like this!

NEW GARDNER-DENVER *HI-LEED* STEEL

Drillers who have used this unique and revolutionary Gardner-Denver thread design are enthusiastic about its convenience and economy. Give it a try on your own rock drills—you'll soon see why. Call your Gardner-Denver drill steel specialist, or write for new bulletin on HI-LEED steel.

Only Gardner-Denver *HI-LEED* drill steel gives you all these field-proved advantages

ALWAYS UNCOUPLES BY HAND

New HI-LEED thread design makes wrenching unnecessary. Gardner-Denver engineers have incorporated field-proved reverse buttress design into an entirely new thread form that always uncouples by hand.

CUTS DRILLING TIME ON EVERY HOLE

HI-LEED steel saves time in adding rod . . . and ease of uncoupling, without use of wrenches, helps drill hole faster.

SENDS MORE IMPACT TO THE BIT

HI-LEED sectional steel transmits drill impact almost as well as a solid rod. That's because precision-milled threads on rod and coupling are in close contact over a large total area, thus holding rod ends firmly together.

DRILLS MORE FOOTAGE PER ROD

HI-LEED rods are designed to last longer than any other sectional steel, and the wide thread peak assures maximum wear. Carburizing and shot-peening give the steel a hard surface and tough inner core.

PREVENTS LOST HOLES

New HI-LEED design keeps mating parts snug—rods won't uncouple in the hole or while pulling out. Other thread forms may not hold a tight connection and many rod strings have been lost in the hole while pulling out with rotation on.

GARDNER-DENVER Since 1859

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

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MINERALS AND MONOPOLY - FORMULA FOR SOVIET STRENGTH

by ALEXANDER GAKNER

East European Specialist, US Bureau of Mines

Since the end of World War II the Soviet Union has made great strides toward economic development of the country. Today it is firmly established as the world's second largest industrial power after the United States and it has committed itself before the people on both sides of the Iron Curtain to catch up with and to overtake us within a few decades. No nation could achieve such a degree of industrialization or aspire to become the world's industrial leader without a large supply of many basic mineral raw materials or at least easy access to such resources. In addition, it requires technical competence, a large skilled labor force, and a high rate of capital investment.

Why should we concern ourselves with these Soviet aspirations? The Free World's yardstick of measuring a nation's well-being is the standard of living of the people in that country. Presumably even Communist governments are committed to some, however gradual, improvement in the standard of living of their people. The population of the USSR is 20 pct greater than that of the United States. Hence, if they ever achieve a standard of living equal to ours, they must by all logic reach a greater overall industrial output. However, in the U.S.S.R. the standard of living of the masses has not kept pace with the expanding industrial production and is still far behind that of the United States. Our concern, therefore, is with what the USSR intends to accomplish with its expanding industrial power: Will they produce large mineral raw-material surpluses and manufacture products to compete with us for world markets and attempt to put us out of business if not use it directly to wage war; or will they use their resources merely to produce more consumer goods for the Soviet people; or will they, along with other Communist nations in the not-too-distant future, compete with us for the world's sources of mineral raw-materials to maintain a high level of mass consumption? Because if all the people of all the Communist nations (comprising one-third of the world's population) should decide that they want a standard of living equivalent to ours, the world's known commercial mineral resources are not likely to last very long.

What do we know about Russia's ability to produce or obtain the necessary ingredients—mineral raw materials, a high level of technology, a skilled labor force, and investment capital—to maintain a rapidly expanding industrial economy for the next decade, two decades, or until the turn of the century? What is the Soviet policy regarding its mineral industries? The Soviet Union did not publish a Report to the President by a Materials Policy Commission; it conducts no public hearings on mineral problems in its legislative bodies; it has no senators to champion one or another mineral policy depending on the interest of a small group within a limited geographic area of the Union. The Soviets don't even publish a Minerals Yearbook to account in detail for their past and present achievements. However, if we examine the overwhelming evidence of their large scale activity in the fields of geology, mining, and metallurgy; the few published statistics on mineral production and foreign trade; and their short, medium, and long-range commitments to maintain an expanding industrial economy, we must conclude that the Russian mineral policy is based on at least three cardinal principles:

1) Maximum knowledge of their indigenous natural resources.
2) Maximum self-sufficiency at almost any price.
3) Long-range planning.

Good or bad, it is quite obvious that the Communist oligarchy of the USSR is aided in carrying out its mineral policy by the fact that all the participating organizations are a monopoly of the Soviet Government. Furthermore, Soviet mineral policy—as part of its broader economic and political policy—is tied directly to its avowed policy of world domination and the elimination of non-Communist free societies. Within the United States the development and use of minerals and metals and the mineral fuels are not regarded as ends in themselves. While we are dedicated to maintaining adequate defenses through mobilization programs authorized by the Stockpiling Act and the Defense Production Act, our

A. GAKNER, Member AIME, is East European Specialist, Division of Foreign Activities, U.S. Bureau of Mines, Washington, D. C.

primary objective in developing mineral resources is to support an expanding economy and the betterment of human welfare. To achieve our goals we have in the past and will in the future continue to rely on a free competitive system.

Twenty years ago we would not have considered it seriously, but today the United States vies with the Soviet Union for political and military prominence and we find ourselves more and more often counteracting various Russian moves. It is as if they are indirectly dictating our lives. In our American society we are guided by the principles of free enterprise and therefore, in the attainment of our goals, we cannot adopt the methods employed in a society of Communist monopoly. However, today we constantly are aware of this Communist society which has dedicated its resources to the destruction of capitalism everywhere. As a result we may have to seek new ways within the framework of our system of encouraging greater investment in our mineral industries and more research in the mineral sciences. Finally, we may have to exercise greater prudence in using our vanishing high-grade mineral resources if we are to maintain our pre-eminent position in the world and perhaps even if we are to preserve our own freedom.

MAXIMUM KNOWLEDGE OF MINERAL WEALTH

In a drive to gain maximum knowledge about its indigenous mineral resources, the USSR, according to an official report of the Soviet Government released last November, employed 398,000 people in 1958. This army of highly trained earth scientists of every type, chemists, semi-skilled technical personnel, and laborers, operated with a budget equivalent to about 1 pct of the country's Gross National Product (GNP), and engaged in geochemical and geophysical exploration, trenching, core drilling, area exploration, mapping, and all other aspects of geologic exploration (not including development work). Volumes on the regional geology of practically every corner of the USSR are being published by the hundreds and prove the magnitude of the Soviet effort to know more about its mineral resources. Because the Western United States has been explored much more extensively than the Eastern frontiers of the Soviet Union, a similar investment in geologic exploration of our country probably would not yield commensurate results.

Individual Soviet trusts, operating on a commodity basis, carefully co-ordinate field findings with their own work in related fields. For example, the Interdepartmental Permanent Committee on Iron Ore is now publishing a 20-volume review (comprising more than 10,000 printed pages) on the geology, proposed mining methods and beneficiation processes, and economic aspects of all iron ore deposits in the Soviet Union.

Partly as a result of this tremendous effort to maximize the gifts of nature, the Soviet Union now claims workable deposits of every single mineral commodity, including industrial diamonds, essential to the maintenance of a modern industrial economy. In many of these mineral products, including most of the major industrial mineral raw-materials—coal, petroleum, natural gas, iron ore, manganese ore, chromite, precious metals, asbestos, phosphate rock, potash—the Russians claim that their reserves are among the world's largest.

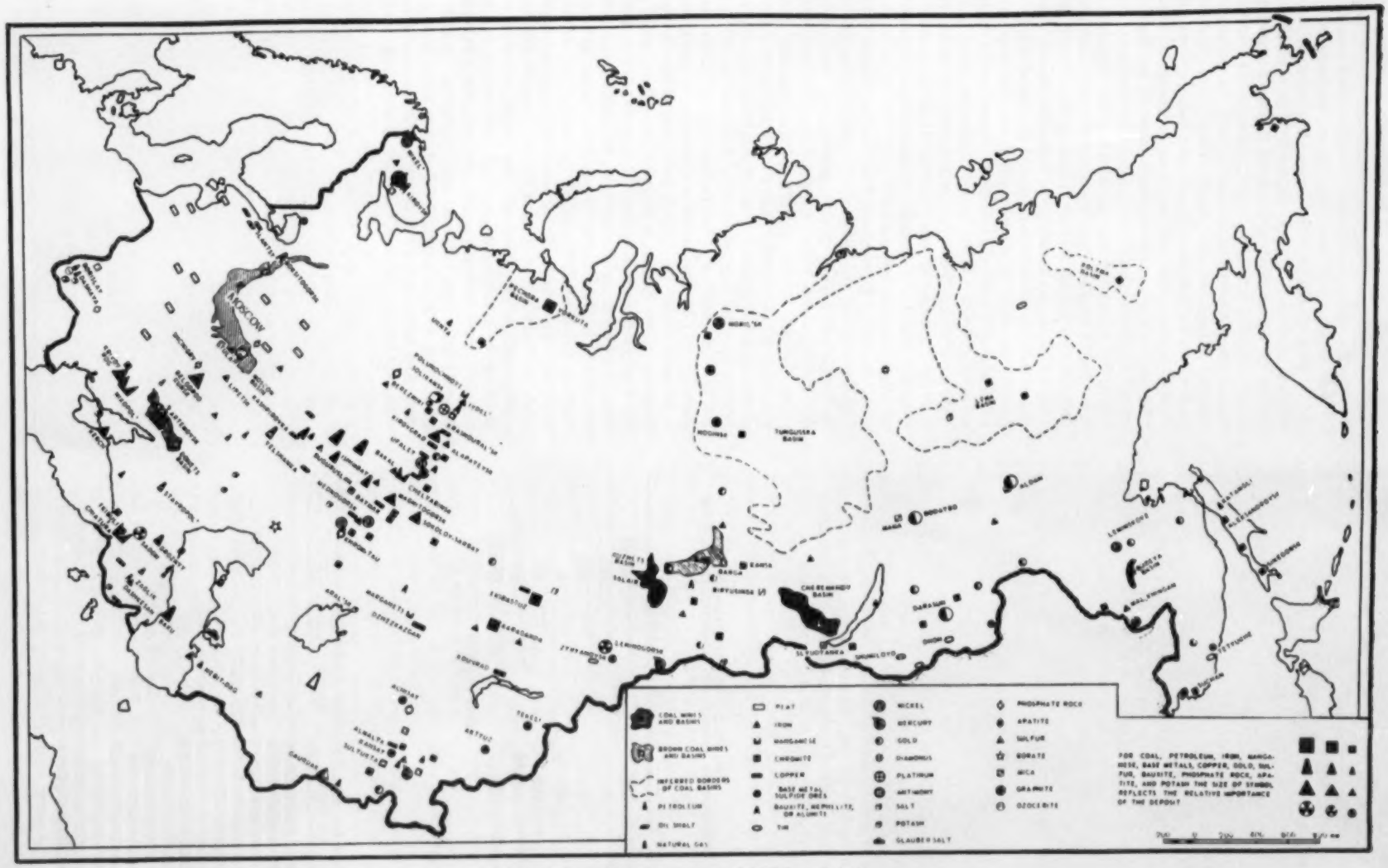
There are generally recognized advantages in knowing what a nation has in the way of mineral resources. When considering the Soviet mineral program, however, specific reasons why the Russians may wish to know more about their resources are evident:

1) The desire for planned development of mineral resources in backward areas of the country.
2) Soviet reluctance to rely on outside sources of mineral supply.

Desire for planned development: Approximately three-quarters of the Soviet population responsible for an equivalent share of the nation's industrial output live in European parts of the country, including the Urals. However, a substantial portion of the country's mineral resources, the Soviet geologists find, are in sparsely populated Asian areas. For example, in the fuels field over 90 pct of the total coal resources, including over two-thirds of the coking coal, and 60 pct of the natural gas are east of the Urals and the Caspian Sea and 80 pct of hydroelectric power potential also is in this eastern area. Nonferrous ore reserves predominate in Asian USSR—practically all the tin, most of the lead, zinc and gold, and more than half of the copper and mercury ore reserves are located there. Of the principal industrial non-metallic minerals, most of the mica, graphite, fluorspar reserves, and the newly discovered diamond deposits are in eastern areas of the country.

Because of diminishing reserves of higher grade ores and deteriorating mining conditions in western USSR and inadequate transportation from eastern areas, the center of gravity of Soviet industry, including its mineral industry, is gradually shifting eastward. In fact, much of the current planning for the future is necessarily based on Soviet Asian resources. Also it is entirely possible that there are other much more profound reasons for the Soviet desire to populate and industrialize the areas bordering China. Whatever the motives, the plans for expansion of the mineral industries in those areas must also provide for developing transportation facilities, a steady supply of skilled labor, a crude metals-consuming industrial complex, and a market for finished products. These are formidable obstacles to overcome in that vast and sparsely populated part of the country.

Reliance on outside resources: Although the Soviet Union appears well endowed with mineral resources, she has been unable to attain self-sufficiency in several commodities, either because of unfavorable location or because of inadequate resources. The USSR continues to supplement domestic production by imports of several minerals, both as metal and concentrate. Copper metal and concentrates; tin, antimony, cadmium, and mercury; tungsten, molybdenum, and lead-zinc concentrates; bauxite, barite, fluorspar, sulfur, talc, strategic grade mica and graphite, magnesite, and piezo-quartz are imported annually from other Communist and Free World countries alike. Aware of Free World nation attitudes toward Communist countries and from recent experience in East Germany, Poland, and Hungary, the Soviet Union apparently is unwilling to become too dependent on foreign sources of supply to meet its mineral and metal deficiencies. For these reasons, the Soviet Union is investing heavily in the development of a large domestic mineral and metal industry.



PRINCIPAL MINERAL DEPOSITS OF THE U. S. S. R.

GOAL OF MAXIMUM SELF-SUFFICIENCY

From information reaching us, it is apparent that the Soviet Union has built a large mineral industry and that this industry is founded on abundant mineral resources. Since 1939, employment in the Soviet mineral and primary metal industries grew 2.5 times to the staggering figure of about 3 million people, while similar employment in the United States fell from 2.6 million to 1.8 million people during the same period. From a nation which three decades ago required foreign know-how and financial aid to develop its basic mineral industries, the Soviet Union has, through heavy capital investment and large employment and despite a devastating war, become the world's second largest producer and consumer of mineral and metal commodities after the United States. On the basis of approximately 40 principal mineral and metal commodities and prices used to determine the value of the United States mineral production in 1958, it is possible to estimate that in 1958 the USSR produced about 18 percent of the world's minerals and metals or about two-thirds that of the United States. Fig. 1 shows the estimated 1958 mineral and metal output of the USSR and its share of the world's total.

There is ample evidence that many of the Soviet mineral raw materials are inferior to those produced or consumed in the United States. Lack of, and sometimes unfavorable, geographic distribution of higher-grade ores makes it necessary to utilize lower-grade ores or to supplement domestic production by imports. Approximately 25 pct, by value, of USSR's total imports are minerals and metals.

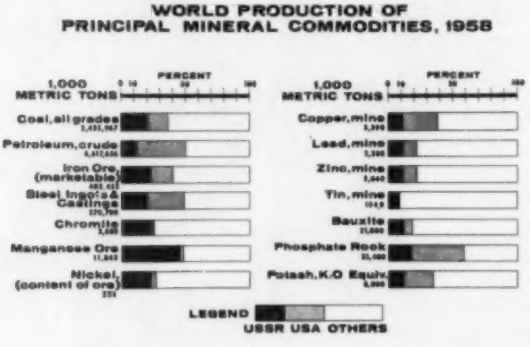


Fig. 1.

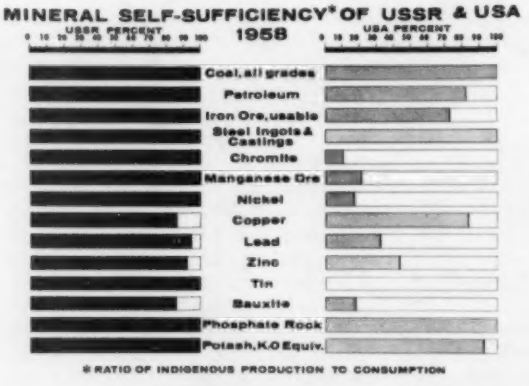


Fig. 2.

For reasons mentioned earlier or because of just plain administrative and labor inefficiency, many Soviet ventures in the minerals and metals field would be denounced as economic failures under the rigid scrutiny of American engineers. Yet, with a totalitarian government, unprofitable operations are readily subsidized (frequently sacrificing maximum growth of the economy) and contribute substantially to the domestic supply and even oversupply which then shows up on international mineral markets. In 1958, minerals and metals accounted for over one-third, by value, of the country's total exports. In the competitive (and unfriendly-to-Communist competition) Free World market, the USSR has certain obvious advantages because Soviet trade organizations are a monopoly of the government of the USSR—the very same monopoly that operates the country's mineral industry. Because the USSR lacks the flexibility and, perhaps more likely, the desire necessary for rapid adjustments in their production patterns to meet world demand, it has in times of world oversupply, demonstrated its ability to cause market mischief.

By choice or by necessity, the Soviet Union today appears to be the most self-sufficient nation in minerals and metals among the world's leading industrial powers. The estimated mineral self-sufficiency of the USSR in the principal mineral commodities is shown in Fig. 2. Let us then, as we contemplate the future, briefly review the Soviet resources and supply in (1) mineral fuels, (2) ferrous metals and ferroalloys, (3) nonferrous metals, and (4) nonmetals and structural materials.

Mineral fuels: The USSR by virtue of its size and location in the Northern Hemisphere where most of the world's known mineral fuel reserves are located, encompasses a major portion of those resources. The Soviet Union claims to have five times as much coal as the United States or 53 pct of the world's reserves. However, if we exclude coal measures with overburdens of over 4,000 ft, inaccessible and highly speculative resources, the Soviet reserves are reduced to a size comparable with those in the United States. Recent Russian sources admit that the commercially exploitable coal reserves now are about one trillion metric tons*, or slightly more than one-half those of the United States. The Russians claim that over 20 pct of their coal, when properly blended, is suitable for producing coke. But they report that reserves of straight coking coals are 60 billion metric tons and that only one-third of this can be mined economically today. Proved reserves of petroleum and natural gas, although still behind those of several Middle East countries and the United States, are also significant, and many geologists believe that the Soviet oil potential is greater than ours. The Soviet Union has the world's largest peat resources and hydroelectric power potential as well as significant reserves of oil shale.

With all these extensive mineral-fuel resources, the USSR still faces perplexing, but not insurmountable problems of efficient utilization because of the distribution of these resources in relation to population and consuming centers, consumer-use patterns, and transportation. These problems are often local.

* Metric tons (2204 lb) are used throughout this report.

As a nation, the USSR is well supplied with every type of fuel resource to meet all foreseeable energy requirements of their economy.

On the basis of its vast fuel resources, the USSR built a large fuel and power industry which provides for all domestic needs as well as for an export market. In 1958 the country produced approximately 700 million metric tons of all forms of primary energy in terms of Standard Coal Equivalent (SCE), including coal, lignite, peat, petroleum, natural gas, oil shale, hydro-electric power, fuelwood, and industrial waste products. This was approximately 50 pct of United States energy production from similar sources during the same year. However, because the USSR is a net exporter and the United States is a net importer of fuel, actual consumption of energy in the USSR in 1958 was estimated at 46 pct of United States consumption.

This latter is a highly significant figure. In a modern industrial society, consumption of energy reflects the level of industrial production. By following the historic development of the energy industries in a country we can obtain a reasonably accurate picture of its industrial growth. Furthermore, by introducing some corrections for consumer-use patterns, efficiency of utilization, climate and geography, this figure reflects, to some extent, the industrial development level of the USSR in comparison to other leading industrial nations. Compared with the United States, the level of all energy consumption in the Soviet Union was 35 pct in 1955; 40 pct in 1957; and 46 pct during the recession year of 1958. Projecting into the future, we can compute, on the basis of the Soviet Seven-Year Plan and average forecasts for the United States, that in 1965 consumption of energy in the USSR will be about 58 pct of the United States total for that year.

Coal is the principal source of primary energy in the USSR (56 pct of total). In 1958, petroleum and natural gas together accounted for 27 pct of the total energy supply. By 1965, according to plan, the role of coal in the energy-supply picture will be reduced to 42 pct; petroleum and natural gas together will rise to 44 pct.

Ferrous metals and ferroalloys: The Soviet Union possesses the world's second largest ferrous metallurgical industry, being surpassed only by the United States. However, it is the only country among the world's leading industrial nations with large high-grade resources of the principal mineral ingredients necessary to make steel—iron ore, coking coal ,manganese ore, and chromite. In 1958, Soviet output of these raw materials exceeded that of the United States. Soviet indigenous production satisfied all domestic needs and provided a substantial surplus for export. During that year, the USSR produced 89 million tons of marketable iron ore, 5.4 million tons of manganese ore, about 800,000 tons of chromite, and 51 million tons of coke.

Head frame in Lvov-Volyn coal basin, Ukraine (1957).

Coal cutter-loader in operation at a mine near Novo-Volynsk in the Ukraine region of the USSR (1959).

The Soviet position in other ferroalloy raw materials is not quite as favorable. Although she appears to be self-sufficient in nickel, vanadium, and perhaps titanium and columbium, domestic production of molybdenum and tungsten must be supplemented by imports of concentrates from China. The USSR also imports substantial quantities of fluorspar from Mongolia and China, and magnesite from China. In general, however, the raw materials supply picture, for the short-term as well as long-term objectives of the Soviet ferrous metallurgical industry, appears quite favorable.

In 1958, the Soviet steel industry, operating at near capacity, produced approximately 40 million tons of pig iron and blast-furnace ferroalloys and 55 million tons of steel. Meanwhile, our own steel industry utilized only 60 pct of our 130 million metric ton steel capacity and produced 77.5 million metric tons of steel. This was about 30 million tons below our average of the preceding three years.

By 1965, the USSR plans to produce 85 million tons of steel and the long-range goal for 1970-72 is 110 million tons (Fig. 3). To all industrial nations, iron and steel are the backbone of the economy. In the United States, like in most Free World nations, the rate of development of the steel industry is primarily determined by the needs of the economy. In the USSR, however, the economy grows only as fast as her expanding steel industry permits. Steel is a symbol of Soviet industrial growth and for that reason production goals for steel—often with disregard to economics—are seldom permitted to fail. We

may, therefore, expect that Russia's goals in the ferrous metallurgy field basically will be met.

The Soviet mining industry is relatively young compared to the United States, but the intensive expansion of the steel industry is already beginning to create certain problems:

1) The Donets Basin, which accounts for about 50 pct of the country's coke, yields high-sulfur coke. The same is true of the Urals' coking coal. Furthermore, the coals in any one basin are not complementary and any blending must be done with coals from different basins. This requires large tonnage coal shipments across the country.

2) Because much of the country's direct shipping grade iron ore is near Krivoi Rog, that area has consistently contributed more than half the nation's iron ore output to meet domestic needs as well as for export commitments to the Satellite nations. Although the high-grade reserves at Krivoi Rog are still large, it has become necessary to go very deep to maintain production. Mining operations are further handicapped by a serious ground water problem. As a result, the production of concentrates from taconites found elsewhere can now favorably compete with high-grade Krivoi Rog ores. In 1955, the crude-to-usable ore ratio for the entire USSR was 1.2 to 1; it is expected to reach 1.4 to 1 this year, and 1.8 to 1 by 1970.

This trend of decreasing quality, still relatively slow in the USSR, also applies to some of the alloy metal resources. Greater effort and correspondingly greater capital expenditures will be required in preparing the lower-grade raw materials.

3) Because of wage increases which reflect a growing general scarcity of labor and perhaps reluctance of the Soviet laborer to work in mines, labor costs in mining have been advancing more rapidly than labor productivity.

4) Partly because of labor shortages, increasing proportions of the investment resources must be spent to replace obsolete and inefficient equipment as well as to take care of normal depreciation in the expanding Soviet industrial complex.

Technologically, the USSR is well prepared to meet these problems. Its mineral industry is making great progress. Modern mining techniques and equipment are being introduced everywhere; coal preparation and coking methods are progressive; preparation and agglomeration of iron ore is at a high level; a large share of the nation's blast-furnaces and open-hearths operates at a level of efficiency comparable to and sometimes ahead of that in the United States. However, the rolling mills and semi-fabricating plants have not kept pace with the general development of the ferrous metallurgical industry. The current Seven-Year Plan presumably provides for the correction of this situation.

Nonferrous metals: In recent years, the USSR has started to export tin, aluminum, zinc, and gold in addition to its traditional exports of the platinum-group metals. Yet the nonferrous metals group presents the weakest link in the Soviet mineral-

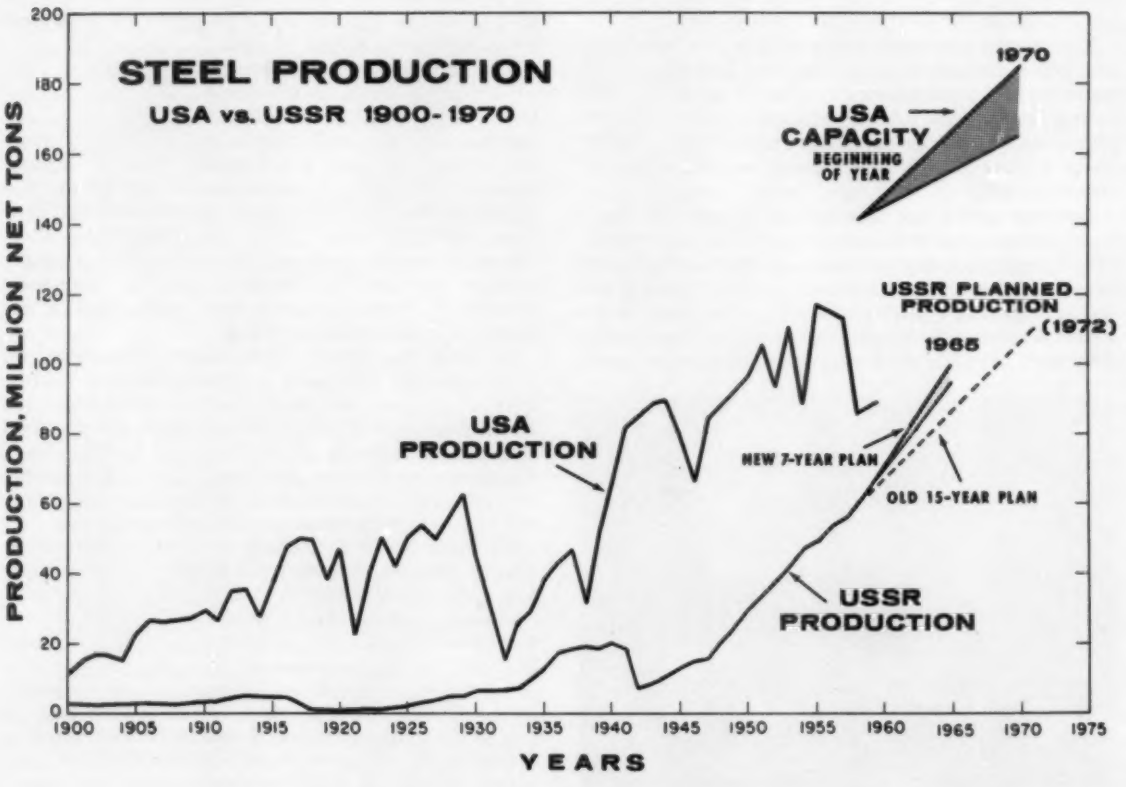


Fig. 3.

supply chain. This is particularly true of the nonferrous base metals or their ores and concentrates which, despite Soviet progress since the end of World War II, continually appear on the Soviet shopping list. The lack of adequate, high-grade resources and the lag between theory and practice in the nonferrous metallurgy field are the principal deterrents to self-sufficiency in this group of metals.

Most of the Soviet shortages of base metals or their ores and concentrates are satisfied by imports from other nations in the Sino-Soviet Bloc. China supplies antimony, mercury, bismuth, and of course, tin. In spite of the sizable Soviet exports of tin, it is basically a net importer of this commodity. Relatively small tonnages of lead and zinc concentrates are delivered from Sinkiang, China apparently as a matter of convenience.

Official Soviet statistics show the USSR as a net exporter of zinc and lead. However, the estimated zinc content of imported metal, ores, and concentrates exceeds its zinc exports while on the same basis lead trade appears to be in balance. The principal source of zinc metal is Poland, and of zinc concentrates, North Korea and Bulgaria. Lead metal comes from North Korea and concentrates from Bulgaria and China. The greatest shortage in the USSR, as well as within the Bloc as a whole is in copper. Although Bulgaria started to mine sizable tonnages of copper ore in recent years, it is unable to make up for the deficit of this commodity and the USSR, along with some of the other Communist nations, buys approximately $50 million worth of copper annually; about two-thirds of it comes from the United Kingdom.

The light metals picture is about the same. While there is no shortage of resources for producing magnesium, the supply of quality raw-material for aluminum is not as favorable. Domestic bauxite resources are relatively small and of poor quality. Since the end of World War II, the USSR has been importing bauxite from Hungary and more recently from Greece along with small quantities of alumina from Hungary and China. In 1958, the USSR imported 450,000 tons of bauxite from Greece. In all, the Soviet Union imports enough raw-material to balance its aluminum metal exports. Continuous efforts to locate high-grade bauxite are apparently not meeting with success because the country is going ahead with plans to expand production of aluminum from nephelite ores.

The USSR is a major world producer of precious metals. Because neither output nor consumption of precious metals are related to the country's normal industrial activity, it is difficult to form a true picture of the Soviet capacity to produce these metals. However, reports indicate large reserves and the export record points to a substantial production. According to informed sources, the value of gold, platinum, and silver exported exceeded $250 million in 1957. Precious metals are a major hard currency earner for the Soviet Union and are used to settle trade balances.

As elsewhere, the rare-metals industries of the Soviet Union developed with the coming of the electronic, jet, and atomic ages. While short on monazite and bastnaesite for the supply of rare earth metals, the Soviet Union possesses an abundance of pegmatite deposits and is nearly self-sufficient in its supply of rare metals which occur in combination with nonferrous base-metal sulfide ores.

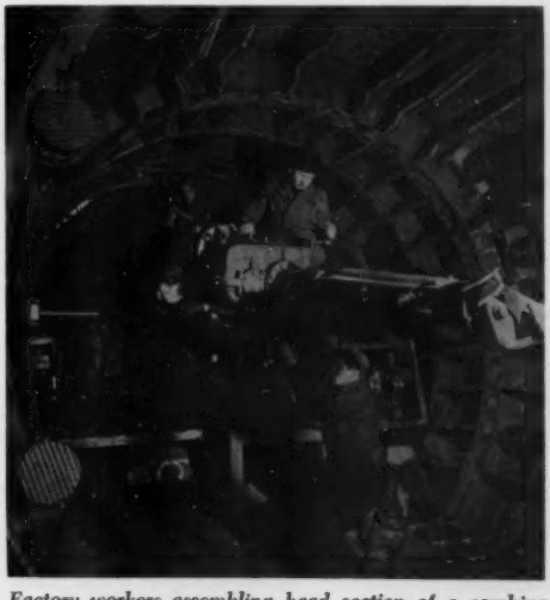
The Kola Peninsula in northwestern USSR will most likely become the country's principal source of columbium, tantalum, zirconium, and rare earth metals. A new city, Zapolyarnoye, is under construction in the area, apparently for the purpose of establishing a new center for exploring the vast columbium, tantalum, zirconium, and rare-earth resources of the peninsula.

Practically all the available information on the Soviet Union's resources of fissionable materials predates the Atomic Age and is therefore highly inaccurate. The pre-World War II reports indicate a virtual absence of high-grade (African-type) uranium deposits. The country is also short on high-grade thorium raw materials, as indicated by the shortages of monazites and bastnaesite. While post-World War II exploration may have disclosed many new resources of fissionable materials, the Soviet Union did not wait for the domestic uranium industry to develop and went ahead to assure a steady and large supply of fissionable ores and concentrates by exploiting the resources of its satellites in Europe and in Asia.

Nonmetals and construction materials: The Soviet Union produces a great variety of nonmetals. The nonmetallic mineral resource position, however, varies greatly from adequacy or abundance of asbestos, china and refractory clays, graphite, gypsum, phosphate rock, potassium and magnesium salts, to an apparent shortage of borax, native sulfur, fluorspar, and *strategic grades* of both graphite and asbestos.

The most significant development in recent years has been the discovery of apparently large diamond deposits in a cold and uninhabited area of Yakutia, Siberia. According to the Soviet Government, reserves of industrial diamonds are adequate to satisfy the country's needs for the visible future, although proper development of the diamond desposits presents a major effort in view of the unfavorable geographical conditions.

The Soviet Union has abundant resources of refractory materials: dolomite, magnesite, refractory-



Factory workers assembling head section of a combine designed for driving levels in manganese pits (1959).

The Yurovsky strip mine in the Ukraine near the city of Vatutino (1956).

grade chromite, and fire clay. The country's position as to fluxing materials is not quite as enviable. Much of the Soviet fluorspar reserve, including complex submarginal materials, is in areas remote from industrial centers or where climate is adverse to proper development of the deposits. In view of the rapidly growing crude steel and virgin aluminum production in the USSR, existing mines are unable to satisfy domestic needs and the country imports over 100,000 metric tons of fluorspar annually from its satellites, mostly China.

The Soviet Union has large resources of mineral fertilizers. The apatite deposits of the Kola Peninsula and the potash deposits on the western slopes of the Northern Urals are unquestionably among the world's largest.

Although the country has large resources of clays, gypsum, and other construction materials, it is not uncommon that certain local areas are short of these materials and suffer due to prohibitive costs of transporting these commodities over long distances.

LONG RANGE PLANS AND FOREIGN TRADE

More than one year ago, the Soviet Union made public a Seven-Year Plan and a tentative Fifteen-Year Plan for the economic development of the country. The principal feature of these plans is that the USSR intends to expand its economy at about 7 pct annually. Thus, for example, output of crude steel is to reach 85 million metric tons by 1965 and about 110 million tons by 1970-72. Production of other mineral commodities is to grow accordingly. Fulfillment of the Seven-Year Plan and of committments made to the satellite nations within the framework of the Communist Council for Mutual Economic Aid has required rapid expansion of Soviet mineral production. Large capital expenditures in the development of mineral and metal industries to assure adequate supplies were made annually as the country turned from a position of many shortages at the end of World War II to one of moderate to substantial surpluses in several commodities which find their way to foreign markets. The bulk of the Russian foreign mineral trade is with other Communist nations as Soviet-styled economic development in Eastern Europe made most of these nations dependent upon the USSR for many mineral raw materials essential to their continued economic development. For example, in 1958 the USSR shipped nearly 12 million metric tons of iron ore to its European Satellites. This was more than these nations produced themselves during that year. Thus, the USSR has a hold on these satellite nations through minerals.

We are not aware of any Soviet policy that calls for the expansion of any mineral industry to produce for export to Free World markets. However, after domestic and satellite requirements have been satisfied, the "overflow" from intra-bloc needs finds its way into these markets where it earns a great deal of foreign exchange for the Soviet Union. In these Free World markets the USSR has a great advantage because its foreign trade is a monopoly of the Soviet Government.

CONCLUSIONS

What then is the Soviet mineral picture and how may it affect us in the future? On one hand we see a large nation which spends a fortune in manpower and capital to locate, investigate, and develop its mineral resources. We see a nation well-endowed in minerals to which maximum self-sufficiency appears an obsession and which has used minerals to exert economic pressure or gain political advantage. On the other hand, the USSR requires 60 pct more people to produce minerals equal to about 60 pct of

our mineral output, by value. Where, then, is the Soviet strength through minerals?

With the present overall state of Soviet technology as applied to the mineral industries of the USSR, it could not compete in world markets unless the Russian people continue to work at substantially lower wages; nor could they possibly achieve a level of industrialization comparable to ours, regardless of the magnitude of the people's sacrifice, if the USSR continues to require 2½ times as many people to do a comparable job. We believe that under equal circumstances, free, competitive societies like ours are much more conducive to efficient operation of industry. But the relative inefficiency of the Soviet mineral industry is not all due to Communist bureaucratic inefficiency. The use of low-grade resources, mining in areas which are accessible only with great difficulty, the use of obsolete equipment, and often the lack of any equipment, and inadequate transportation are among the other reasons behind the low productivity in the USSR.

There is a possibility, however, that with a continuous high level of capital investment and with technologic progress they can, in time, overcome all these difficulties sufficiently to offset the inefficiency inherent in a large bureaucracy. They have demonstrated their readiness to invest capital in their economy at a higher rate than we and to speed technologic progress through mass education. There is no monopoly on education or technologic progress that has made it possible for the United States and some other countries to mine profitably mineral deposits which, not so long ago, were considered submarginal.

Thus, if there is any merit to the contention that there are ways in which the Soviet economy may progress successfully, then the Soviet strength is not in the fact that it has discovered a low-grade tin deposit in Siberia or native sulfur in the middle of the Kara-Kum desert. Nor is it in the fact that it produces many mineral commodities at prohibitive costs. Rather, it lies in the Soviet's apparent determination to overcome these problems and to maintain its unity of purpose. Thus, there is great potential strength in knowing the quantity and quality of indigenous natural resources—the building blocks of the future industrial economy of the USSR. Whatever the political considerations, the Russians have

Coal-face of the OGPU mine at Rostovugol is completely equipped with metal props. (Date of photo unknown).

View of the first fully mechanized vertical coal mine, Karaganda area southwest of the Ural Mts (1959).

already demonstrated their ability to attain a high level of technology which, in some applications, is comparable to ours and sometimes ahead of ours (to mention space technology in particular). Soviet efforts in geology and the related sciences are both extensive and intensive. The emphasis in the earth sciences seems to be placed on a pragmatic approach to even ordinarily academic disciplines—giving a goal and a push to most studies. Particularly advanced work is being carried out in the fields of chemical, optical, and X-ray mineralogy; geology of ore deposits; petrology; ore genesis; geochemistry; and geologic mapping.

Progress is being made in the field of mining. The application of block-caving and open-pit mining is growing. Soviet efforts in underground mining of coal by hydraulic methods are noteworthy. The assortment and quality of mining equipment is growing. Mineral research is extensive.

Coal technology compares favorably with that of most large coal-consuming countries. Notable are Russia's research efforts in aluminum reduction (high-current-density, electrodes) and copper smelting (cyclone furnaces). The Russians are already known to have achieved high performance from many of their blast furnaces through the use of sized, self-fluxing feed, plus top pressure and oxygen-enriched blasts.

Because of the large volume of research and the pressure on Soviet scientists, their efforts often result in premature conclusions and broad generalizations, but we cannot deny that great progress has been made in the mineral industries of the USSR. Rich mineral resources and the Communist monopoly have produced these results. National planning and the orientation of all national energies to the attainment of objectives that are possible under Soviet autocracy have achieved many remarkable and—to the Western World—shocking material accomplishments.

We may derive some consolation from the thought that the price paid in freedom is too high or that the Communist regimentation cannot survive in a society where the yearning for individual freedom fundamentally must be strong. We would be wise, however, to recognize that in its growing mineral strength, the USSR has the wherewithal to back up its desire to wield power in world affairs.

AERIAL MAPPING AT ESPERANZA

by F. H. BUCHELLA, JR.

When Duval Sulphur & Potash Co. awarded premining stripping and early mining at Esperanza to an independent contractor, it was agreed that monthly payments for excavation were to be made on a truck count. At six-month intervals, however, adjustments must be made on the basis of actual excavation or cut from the pit area. It was estimated that it would be three times more expensive to have the pit sectioned by chain and transit survey than to use photogrammetry, since it would take two crews of three men approximately two weeks to do the field work, another two weeks to plot the sections, and additional time to establish a control network. Therefore it was agreed to have the mine area mapped by photogrammetry for both the premined surface and for semi-annual check surveys necessary for intermediate settlements.

A triangulation net was established with a maximum distance of 900 ft between control points. In about 30 working days a two-man survey crew, using a theodolite, set up and triangulated 30 stations and calculated their results. For ease in spotting on the photographs, control stations were marked on the ground with white-painted tires centered over the survey pins.

The area was photographed with a 6-in. precision camera from an altitude of 1500 ft above the approximate mean terrain at a scale of 1:3000. A contour map on a 1:600 scale, with 4-ft contours on the slopes and 2-ft contours on the flats, was constructed with a Kelsh plotting instrument, covering a 4500 x3400-ft area. This map was made in four sections with coordinate lines on 250-ft centers. The aerial mapping company guarantees 90 pct accuracy within one-half contour interval and the remaining 10 pct within one contour interval. Transit and chain random sections have verified this accuracy.

Cost of the initial flight and maps was $3075, including two sets of photographs and two sets of Mylar tracings. At six-month intervals the pit area is reflown, photographed, and mapped to determine the progress and the tonnage moved during that period. The cost of four such reflights has averaged $1600 each. Any new triangulation stations required are located and tied into the original net. Many of these stations are already established for daily use in pit surveying.

The company's agreement with the contractor required vertical sections initially on 50-ft centers and eventually on 25-ft centers. These sections were to be taken from the topographic maps of the premined surface and the semi-annual progress checks for calculation of payment quantities. Duval engineers questioned the work and expense of transferring information from topographic maps to vertical sections when the maps themselves offered horizontal sections in a far greater number than required vertically. After careful study of the two systems Duval engineers, with contractor agreement, decided to use horizontal sectioning to determine excavation from the pit.

The topographic maps were divided into 5x10-in. blocks, a size readily covered by a compensating polar planimeter without shifting the pole. Each block was delineated by coordinates and further identified by a number which is retained throughout successive check surveys and computations.

The volume or tonnage in each block before mining was calculated from the initial maps using the original ground contours. The contour areas were planimetered starting from the highest elevation in the block, which is of zero area, to 50 sq in., which is the lowest elevation and the datum plane of that specific block.

Contours planimetered depend on the uniformity of the terrain. In some cases 20-ft contour intervals are sufficient for accuracy, but in irregular or flat terrain 4-ft or even 2-ft contours are used. The closer the contour interval the more accurate are the results. Close contour selection is essential for accurate results along tops of knolls and ridges and in valleys and canyons. A limit of 20 vertical ft was generally adhered to even where uniformity of terrain indicated the acceptability of a greater interval.

After a check survey has been made, the progress maps are divided into the same areas or blocks as before and the same procedure is followed in calculating the indicated volume remaining in any one block. Normally this volume when subtracted from the original calculation gives the total excavation or *cut* quantities. The one exception is the occurrence of fill quantities within a block. Fill quantities within pit boundaries are quite small and are limited primarily to road construction and kept to a minimum, but they must be determined so that total excavation can be calculated. Fill quantities within pit limits are not considered in the payments until a final adjustment is made and are therefore necessary for subtraction from the cut. The fill areas are not apparent on the progress maps but are easily detected by comparison with the originals on a light table. Where fill occurs, the original contours are traced in red on the progress maps and the total volumes in the blocks are calculated by planimetering these original ground contours underneath fills; by subtraction from the original volume, a true *cut* quantity is determined. The apparent *cut* quantities determined from the printed contours are subtracted from these true *cut* quantities, leaving the amount of the fill. The fill is then reduced to the in-place value by a factor of 62.5 pct and deducted from the actual cut for a final payment adjustment. As the pit expands these fills are being removed and are disappearing from calculation work.

Since each check survey is treated independently of the preceding one and compared with the initial

(*Continued on page 577*)

F. H. BUCHELLA, JR., is Ore Control Engineer with Duval Sulphur & Potash Co.

View of Esperanza mine at initial stage of development.

The Esperanza Pit as it appears today.

NEW SAFETY PROGRAM AT CHINO STEPS UP PRODUCTION, LOWERS COSTS

by PAUL L. HUNTER

Nearly 2000 people are employed at Kennecott's Chino Mines Division, which recently completed its 50th year as a leading copper producer. Chino operates an open pit mine at Santa Rita, N.M., and a reduction plant, including mill, power plant, and smelter, at Hurley, N.M. The property mines 66,000 tons of copper ore and materials per day.

There have been safety and industrial health programs at Chino for a number of years, but in 1955 these procedures were reorganized on a more active basis. The following discussion evaluates the progress made during the 1955-1958 period.

As compared with compensation expenses for the previous ten-year period, savings under the new program amounted to $60,000 annually. This estimate does not include medical expenses, damage to equipment, loss of production, or overtime replacement costs. When all the factors involved in accident costs were considered, savings during the four-year period totaled $250,000.

What changes were made in accident prevention methods to bring about this reduction in costs? These key questions will be considered under two categories: 1) the accident prevention program, and 2) the industrial health program.

ACCIDENT PREVENTION PROGRAM

Reorganization of the accident prevention effort included at least seven major projects, incorporating many changes in all phases of safety:

1) A mandatory protective equipment program.
2) Effective communication, stressing safety.
3) Elimination of hazards through routine and preventive maintenance.
4) Built-in safety through equipment purchase control and safety design for new construction.
5) Emphasis on supervisory responsibility by training and merit rating methods.
6) Use of promotion campaigns and contests to create employe interest.
7) Union participation.

These aspects of accident prevention are certainly not new. But such measures were not entirely responsible for the good results of Chino's program.

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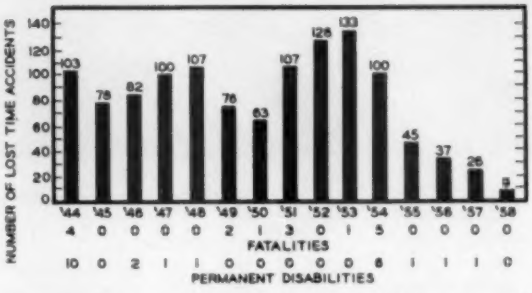


Successful accident prevention originates with the top management men in any organization, and without their active support a safety program has little chance to succeed. The emphasis they place on safety is reflected in the attitudes that supervisors and employes adopt toward the program.

Sometimes a situation is camouflaged under so many disguises that it appears extremely complex. In dealing with accident prevention, the men in Kennecott's top management have avoided making a complex problem out of a simple equation. They stress the fact that safety is efficiency. Accident prevention can be justified when it is considered a component of efficiency. A simple equation can be developed to expound this theory, which must be the groundwork for accident prevention programs.

Skills + Tools = Production Potential [1]

Tools are defined as all assets of the property and production equipment available. Skills are the inherent abilities and experience of the working group. Since *production potential* is not an end product, it is necessary to realize this potential before it is possible to perform efficiently.

Production Potential + Incentives + Supervision = Production Output [2]

For production potential to be realized, employes must have a reason to perform it; it is necessary to provide incentives, such as wages. But incentive in itself is not enough. Someone must coordinate, train, plan, and direct these activities toward a central goal. Supervision must be added to the equation to insure maximum productive effort. A

basic equation for production has now been developed which can also be applied to accident prevention, that is:

$$\text{Skills} + \text{Tools} = \text{Safety Potential} \qquad [3]$$

It can certainly be said that the employe's skill plus the tools he works with are the two basic factors in safety. Common sense assures us that the better the tools and skills a man uses, the more safely he can work.

$$\text{Safety Potential} + \text{Incentive} + \text{Supervision} = \text{Safety Record} \qquad [4]$$

Here again, the potential must be realized, and to do this, the employe must be aware of the reason. The incentive for working safely is the same as for production plus the human incentive. It would seem that the added *survival incentive* would insure greater awareness of safety than of productive efforts. Chino's accident records indicate that the survival instinct is not as great an incentive to produce safely as it would appear. Industrial employes can and do knowingly subject themselves to needless hazards. People must be trained, directed, coordinated—in brief, they must be supervised. Imagine the confusion that would take place during marching drills on a parade ground if all drill instructors were to stop issuing orders in the middle of a maneuver.

Analysis of Equation Factors: Management is aware of the need to employ the best available skills. When we hire a timber man or machine operator, we are naturally looking for the best on the labor market. This is nothing new. Management hopes to select the best orebody available and must supply the most efficient machinery and methods to produce ore at the lowest cost. Company executives are aware, then, of how to achieve the production potential from an operation. Also, they know that they must pay the going wages, since they are competing for the best skills on the existing labor market. The factors of skills, tools, and incentives are relatively static, while the remaining element of this equation—i.e., supervision—is considerably more flexible.

Skills are limited by the area's labor market. The tools are often limited by the physical aspects of the orebody and the capital investment available or authorized. Incentives are limited by many factors —the economics of the area, labor unions, management policies, and economic conditions.

While supervision is also somewhat controlled, management certainly has more freedom for development of its supervisors than for any of the other factors. Proper supervision trains, develops, and applies basic skills to the best utilization of tools. Through the proper exercise of leadership, it can exert an important influence on the incentives factor. Poor leadership can completely destroy incentives to produce safely, and good leadership can multiply the effects of the system.

$$\left.\begin{array}{l}\text{Skills}\\ +\\ \text{Tools}\\ +\\ \text{Incentives}\end{array}\right\} \times \text{Supervision} = \text{Safe Production}$$

Possibly this presentation has been oversimplified in order to emphasize the importance of *good* supervision. Accident prevention itself is relatively simple, and yet so many speak the words without realizing that good supervision is responsible for safe as well as efficient production. This theory can be communicated only by uncomplicated reasoning.

INDUSTRIAL HEALTH PROGRAM

These are changing times, and no longer is it economically possible to ignore the physical aspect of good employment practices. It can be demonstrated beyond doubt that over a period of years, a sound employment policy can increase a company's profits significantly.

It has been emphasized that we try to hire the best skills available on the labor market and that we use supervision to train and schedule and direct these skills toward maximum efficiency. But are there other factors to be considered? After the goal of developing and directing individual skills has been achieved, there is still great variance in individual daily performance. This wide variance between individual potential and actual performance must be considered.

Assume one of the causes of this variance to be *employe health* and assume the word *health* to mean all things *physical* or *mental* which affect the employes' performance. The fact that some health factors are definite problems can be in part substantiated by a safety survey made at Kennecott Chino Mines Division. The survey reviewed all accidents, regardless of seriousness or type, at the reduction plant for the period 1944-1957. A total of 3966 accidents was studied and compared to an average employment figure of 1018.

This would seem to indicate that the average employe should have experienced in the neighborhood of 3.9 accidents. The survey showed, however, that 72 employes sustained 980 of the accidents studied, or that each of this group averaged 13.6 accidents as compared with the expected average of 3.9. In terms of percentages, 7 pct of the employes sustained 25 pct of the accidents. These statistics were studied carefully and all factors weighed to assure reliable conclusions.

It is clear from this that some employes' safety performance is better than others. Moreover, it follows that some workers are consistently more productive than others.

But the survey would not have been complete unless this variance in safety and production performance could be traced to some aspect of industrial health:

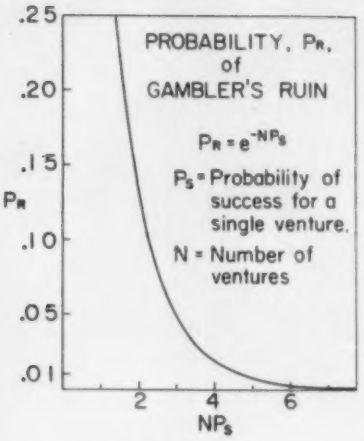
1) Physical health.
2) Mental health.
3) Environmental health (working conditions, pleasantness, moral, etc.).

These results encouraged further studies. If this health factor affected safety, then it must have equal effect on production.

One cause of the low efficiency was physical health. It was decided that each of the 186 supervisors should be asked to submit the names of employes whose physical limitations prohibited them from performing 100 pct of the duties listed on their job description. After the lists had been compiled and studied, it was an easy matter to compare the physically handicapped with the 72 employes who had a large percentage of the accidents. The two surveys were conducted by disinterested parties and were entirely separate, both groups

(Continued on page 577)

THE 1960 JACKLING LECTURE



THE NEED OF A NEW PHILOSOPHY OF PROSPECTING

by LOUIS B. SLICHTER

Prospecting is certainly the world's biggest and best gambling business. It is a game where the chips cost many thousands and where many millions, even billions, can be won. An attractive feature of this gamble is the fact that the players are free to rig the odds as favorably as possible. Only the limited bounty of nature, the restrictions of the laws of the land, the competition from other players, the limited sagacity of the player himself—only these, and other factors, restrict the possibilities for large winnings.

Today probably about half the land surface of the earth remains to be searched for signs of ore visible at the surface. It is fortunate that so much land still remains for exploration by relatively economical methods. Looking to the future, it is a good guess that the costs of finding ore will increase in response to increasing technical difficulties. To continue to achieve profits from prospecting, it will become necessary to analyze the business more skillfully, in a more and more sophisticated manner. Whenever feasible, qualitative concepts must be replaced by their quantitative equivalents, improvements, and extensions.

THE GAMBLE

The fact that prospecting is a gambling business reminds us at once of the elementary rule known as the *law of gambler's ruin*. I hesitate to mention so simple a rule in this company of experts. This rule expresses the rather serious chance of going broke when the odds for success are small, merely by a normal run of bad luck regardless of the long-run expectations of gain. The only sure way of avoiding this special risk of *gambler's ruin* is to have enough capital, and the will, to continue the play many times and thus ride out the inevitable runs of bad luck. For example, if the probability of success is one in ten for each venture, there is a 35 pct chance that ten successive ventures will fail in a row. But if one has the capital to continue the play through a run of 100 failures, then the chance of *gambler's ruin* is only 5 in 100,000. Almost any management, I suppose, would be under terrific pressure to cease the play during a long run of bad luck. To continue to prospect under such circumstances requires great confidence in the premises, and a firm conviction in the long-term expectation of profit. There is evidence which I shall mention that in the future even the strongest companies may not have the necessary capital to prospect on the ideal scale. Joint ventures will be very desirable as a means for extending the available venture

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capital. The essential difference between the fascinating business of prospecting and the more prosaic insurance business lies in the law of *gambler's ruin*. The insurance companies place so many thousands of bets that they are obviously immune from the hazard of *gambler's ruin*. Mining prospecting is *not* thus immune and qualifies as an excellent example of a first-rate gambling business.

STATISTICAL ANALYSES OF OREBODY OCCURRENCES

The use of geophysics and geochemistry in prospecting, and especially the use of the airplane, changes the character of the operation from the bird-dog search for special situations, used by the old-timers, to the wholesale uniform search of large tracts of land. The unit of coverage appropriate for an airplane, say 1,000 to 10,000 sq miles, is so large that the statistics of orebody distributions may become basic in determining rational prospecting plans. As the areas explored become larger, the details of the special situations, strikes, dips, sizes, and other characteristics of the orebodies become submerged in the so-called *law of averages*.

Areal Distribution: A familiar qualitative statement about the statistical distribution of orebodies is the axiom *more ore is to be found near known mines*. This axiom may be given quantitative expression in terms of the observed distribution of known mines throughout large mining areas. Suppose that a large mining area is subdivided into many equal units of a size, for example, of 1000 sq km. On average, how many mines occur per unit, and what is the chance that a unit of area will contain at least n mines where n is 0, 1, 2, 3, etc? A good beginning has been made in the study of such questions. Under suitable conditions, Allais and Blondel[1] find that the areal distribution of orebodies is well represented by the familiar Poisson distribution. The Poisson type of distribution is very commonly encountered. For example, on a long stretch of open highway, the spacing of cars accords with the Poisson distribution. Again, in prospecting for uranium, the random clicks of a geiger counter are spaced in time in this way.

Returning to the distribution of mines, let us divide the area of 125,000 sq miles—centered at Boulder Dam—which was studied by Nolan[2] into 357 squares of 1000 sq km each and examine the distribution among these subdivisions of the 154 mining districts which have produced in excess of $10,000. Similarly, the Precambrian intrusive and sedimentary areas of Ontario were divided into squares of 1000 sq km each (185 in number) and the count of mines, square by square, recorded. (Mines within two miles of one another were counted as a single mine.) The results of such counts for the two regions are shown in Table I. Here the first column represents n, the rank of a 1000-sq km square in respect to the number of mines now known within it. In the second column are listed the number of unit squares containing precisely n mines. The third column lists the percentage of these areas which contains n or more mines. For example, in the Basin and Range region, two or more mines are found in 9.5 pct of the sub-areas. The mean number of mines per 1000 sq km is 0.43 in the Basin and Range area, 0.80 in the Ontario area.

These results are presented graphically in Figs. 1(A) and 1(B). The scale of ordinates which is logarithmic represents the probability $P(n)$ that n or more known mines will occur in any randomly chosen unit square. The plotted points which represent the observed counts are well presented by the straight lines $P(n) = 10^{-0.51n}$, $P(n) = 10^{-0.80n}$, respectively, in the two regions. The two associated graphs which are concave downwards represent theoretical accumulative Poisson distributions having the appropriate means, 0.43 and 0.80 respectively. It is clear that the straight lines representing the exponential functions provide a better fit to the data than do the Poisson curves. The exponential probability distribution has important implications. It implies that the chance that one or more additional mines exist in any unit is *independent* of the numbers that are already known to exist. There is no indication that a unit of this size has been appreciably depleted in potential undiscovered wealth because some two, three, or four mines have already been found. The statistics indicate that the mines are there to be found and that the lack of discov-

SUGGESTED READING FOR BASIC CONCEPTS OF STATISTICAL ANALYSIS

1. Bennett, C. A. and Franklin, N. L.: *Statistical Analysis*. John Wiley and Sons, 1954.
2. Hald, A.: *Statistical Theory With Engineering Applications*. John Wiley and Sons, 1952.

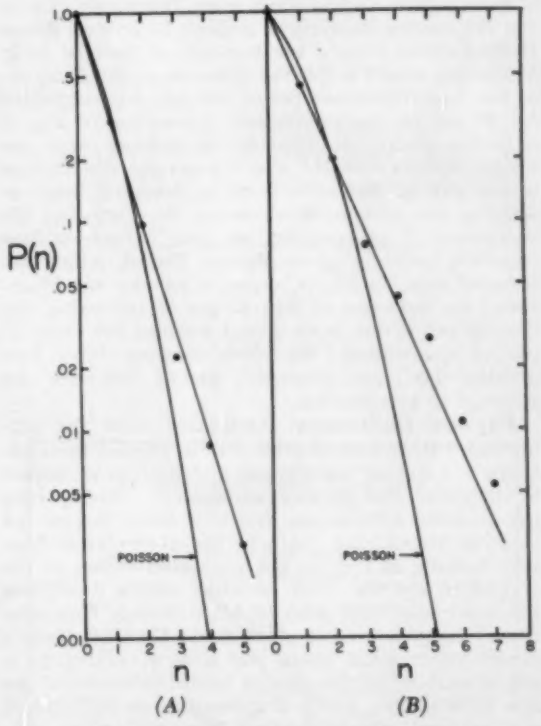

Fig. 1—(A) Comparison of observed distribution of mining districts in Basin and Range area with Poisson distribution. (B) Comparison of observed distribution of mines in Precambrian intrusive and sedimentary area of Ontario with Poisson distribution. Note: Ordinate P is the probability that a unit area (1000 km²) will contain at least n mines, where n is 0, 1, 2, 3, etc.

eries is attributable to difficulties of discovery rather than absence of targets for discovery.

If the Poisson approximation were valid, the axiom *look for mines near known mines* would be bad advice, in a narrow sense, since in such a distribution there is less chance of finding more in areas where the density is already high. No doubt the reason for the truth of the adage is the fact that more adequate geological information is revealed in the known mines. Thus the rule probably means not that mines are more abundant but are easier to find in the neighborhood of known mines. The statistical evidence here presented indicates that the abundance of *undiscovered* mines in these areas so much exceeds the few per 1000 sq km that have already been discovered that these discoveries do not reduce to any appreciable degree the number remaining to be found. Much more extensive studies of mine distributions in many other regions are of course needed. Such statistics may contribute significant evidence relative to the abundance of undiscovered mineral resources. The areal distribution of orebodies is obviously a basic consideration in the rational planning of prospecting.

Distribution of Orebody Values: Another familiar assertion about prospecting is the statement that the rare big orebodies—the so-called *elephants*—furnish the real rewards. This axiom seems to be accurately expressed quantitatively by the statement that the logarithms of the values of orebodies are distributed in accordance with the normal law of errors. Like the Poisson distributions, the log-normal law is also very frequently encountered both in nature and in economics. The production of the 285 mining districts in Nolan's Basin and Range study follows closely the log-normal pattern (Fig. 2). In this area 4 pct of the districts produced 80 pct of the wealth, and 16 pct of the districts accounted for 97 pct of the production. According to Fig. 2, only one district in 1000 would produce over one billion dollars. Clearly, the log-normal distribution in the size of orebodies leads to dramatic implications in the economics of search. In discussing the economics of prospecting an area of one million square kilometers in the Sahara Desert, Allais[4] estimated that the single largest discovery would account for between 35 and 40 pct of the value and that 25 pct of the finds would account for 65 to 80 pct of the values. We shall consider later how greatly the large orebodies should influence the strategy of prospecting.

Physical Dimensions: Associated with the log-normal distribution of orebodies in respect to value, there is a similar log-normal distribution in respect to their size and physical dimensions. Clearly both the absolute dimensions, and to a lesser degree the relative dimensions (namely the geometrical fineness ratios), as well as the associated values of the orebodies, are the chief variables which determine the most profitable plan of blind search. However, it may happen (and it often does) that satisfactory direct information about the sizes of orebodies is not available. In this case, a useful estimate of the size distribution, which is insensitive to the kind of ore involved, can be derived from the known distribution of the orebodies in respect to value. For example, within a factor of about 2, the average ores of ten important metals from gold to iron carry the same values per pound, or per cubic foot.[5] Thus one may adopt a standard factor to convert value to volume, which for convenience I shall assume to be about $1.00 per cu ft.

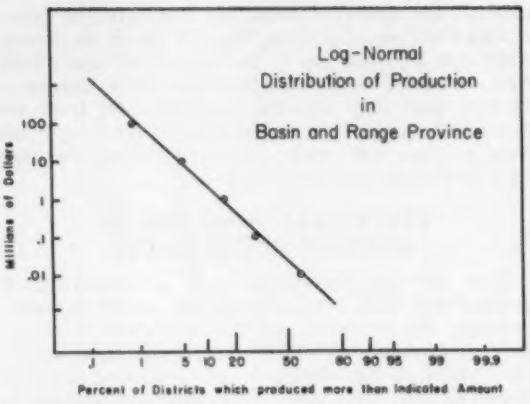

Fig. 2—Log-normal distribution of production in Basin and Range area. (A straight line on this graph represents a log-normal distribution.)

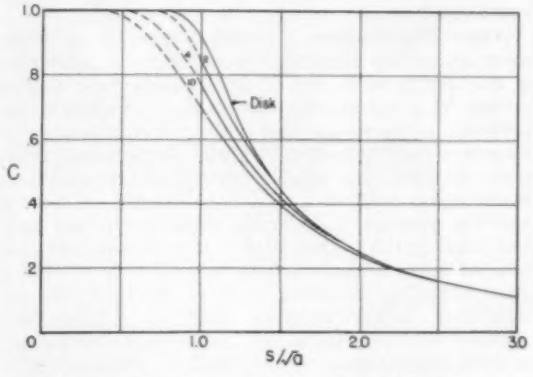

Fig. 3—Completeness of search by drilling grid.

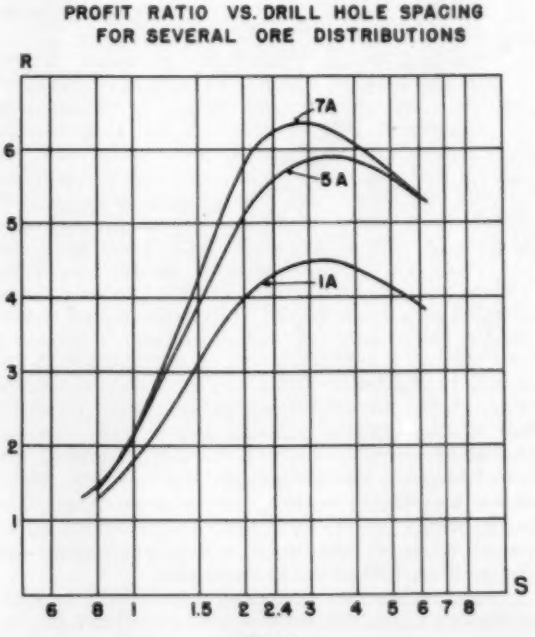

Fig. 4

PROBABILITY OF DISCOVERY

Having briefly considered the distribution of targets in space and in size, I shall next discuss some search problems in prospecting for blind orebodies. In these search problems, the basic compromise dictated by economics is between the completeness or thoroughness of search and the cost of such thoroughness. Usually the desirable compromise is that which maximizes the ratio of profits to cost.

Prospecting by Drilling: In some simple types of exploration problems, notably in exploration by the drill, it is feasible to calculate the probable completeness of search in terms of the size and shape of targets, and in terms of the drillhole spacing. Thus one can determine the best spacing of the drillholes. Fig. 3 shows the completeness of search for randomly oriented orebodies of various fineness ratios as a function of the drillhole spacings. The important item here is the ratio of the area *a* of the target to the area associated with each drillhole of the pattern. Long, thin bodies are somewhat more difficult to find than equi-dimensional bodies of the same area. A computed example appears in Fig. 4 showing the effect of hole spacing on the prospecting profit ratio.*

Prospecting by Geophysics: Let us turn now from prospecting by the drill to prospecting by geophysics, and in particular to prospecting by the airplane. In the geophysical search problem, one of the important questions concerns a suitable meaning for the word *discovery*. If a drill strikes good ore, one does not quibble much about the meaning of *discovery*, but a geophysical survey may reveal many so-called *anomalies*, most of which are not caused by ore. The identification of potential ore anomalies among similar effects caused by other geologic influences remains a first-class problem. Better ways of appraising the significance of geophysical anomalies, and of distinguishing them from the background of geologic noise, are needed and indeed are being continually developed.

Obviously, in the last analysis, the dangerous role of personal judgment or intuition in identifying and appraising anomalies can be eliminated only by performing the entire job mathematically.

For the present, however, let us avoid the complex subject of the interpretation of geophysical maps, however fascinating this may be. Let us agree for present purposes that the word *discovery* means only that the geophysical anomaly is crossed by at least one traverse, or better perhaps, by at least two, or if you prefer by at least three.[5] The point here is that one needs enough data to develop the outlines of a significant geophysical indication, and so the number of *discovery traverses* needed depends upon the local circumstances.

With this definition one may compute the probability of discovering targets of various sizes and shapes by surveys having various traverse spacings. In one case, at least, it is well known that the results may be expressed in a very simple way, namely, when the traverse spacing exceeds the major horizontal dimension of targets of any convex shape, which are randomly oriented, then the probability of discovery is proportional only to the perimeter of the target. In Fig. 5 the perimeter of elliptical targets is shown plotted against the major dimension. When the fineness ratio *a/b* is greater than 3, the perimeter is essentially proportional to

*These examples are more fully discussed in reference 4.

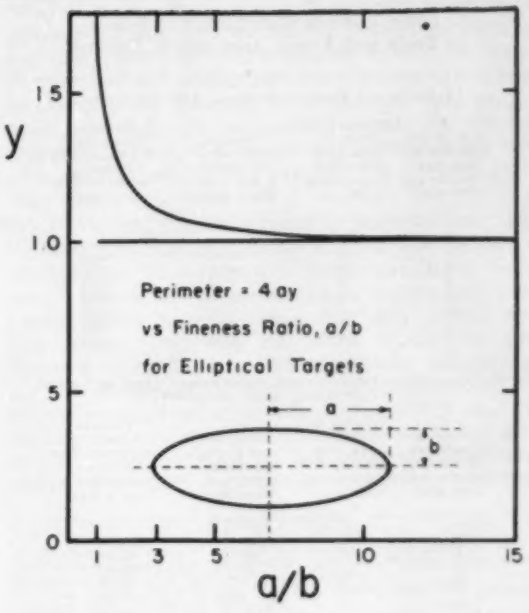

Fig. 5

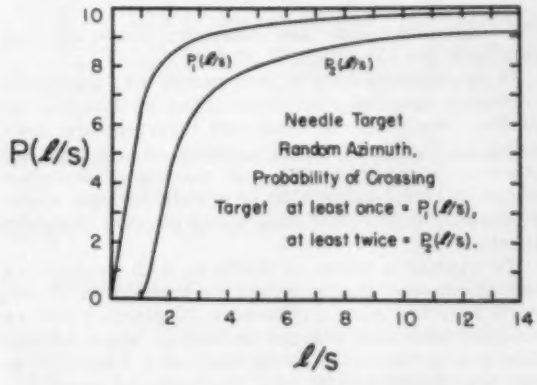

Fig. 6

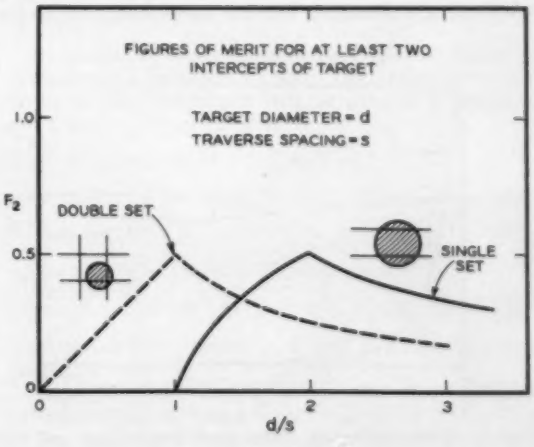

Fig. 7

Table I. Areal Distribution of Mines in Basin and Range Area and in Ontario

A. Basin and Range (154 Mines, Area 357 Units)

n = Areal Density of Mines in Number per 1000 Km²	Number of Units of Area 1000 Km² Each Containing n Mines	Percent of Units Containing n or More Mines	Percent According to Cumulative Poisson Distribution (ε = 0.43)
0	250	100.00	100.00
1	73	29.97	34.88
2	26	9.52	7.01
3	5	2.24	0.81
4	2	0.84	0.06
5	0	0.28	0.00
6	1	0.28	0.00
7	0	0.00	0.00

B. Precambrian Intrusive and Sedimentary Areas of Ontario (147 Mines, Area 185 Units)

n = Areal Density of Mines in Number per 1000 Km²	Number of Units of Area 1000 Km² Each Containing n Mines	Percent of Units Containing n or More Mines	Percent According to Cumulative Poisson Distribution (ε = 0.8)
0	104	100.00	100.00
1	45	43.78	55.07
2	22	19.46	19.12
3	6	7.57	4.74
4	3	4.32	0.91
5	3	2.70	0.141
6	1	1.08	0.0184
7	1	0.54	0.00207
8	0	0.00	0.0000

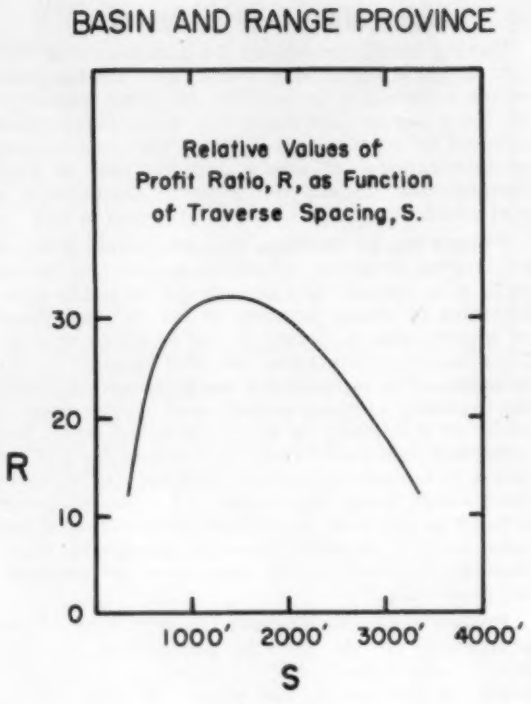

Fig. 9

the major dimension; the maximum deviation from this rule, for the circle, is 57 pct.

In the extreme case of long needle-like anomalies randomly oriented, the probabilities of detection by at least one or by at least two traverses are indicated by Fig. 6. Probability curves of this type are basic in determining the best spacing of traverses either in aerial surveys or in ground surveys where essentially continuous data along parallel lines are taken.

To express a *factor of merit* in such prospecting operations, one should divide the probability of discovery by the cost of discovery. Neglecting for the moment overhead charges, it will be assumed that this cost is merely a flying cost, at a fixed charge per mile flown. In this case, the factor of merit F is proportional to the probability of discovery times the spacing between traverse lines.

In the important limiting cases when the orebody is near its maximum detectable depth, there is a well-known tendency for the geophysical anomaly

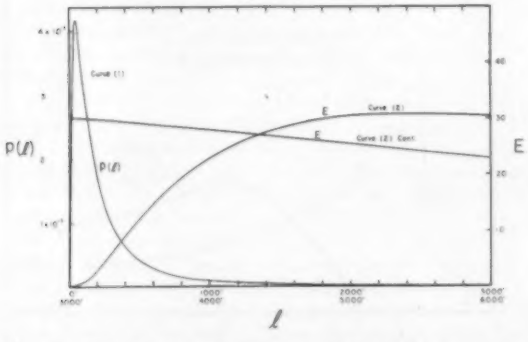

Fig. 8—Distribution of Basin and Range-type ore occurrences as to length (Curve 1) and value (Curve 2).

to become much more equi-dimensional than is the causal orebody. For this reason the other extreme case, namely the problem of detecting a circular disk, is of interest. For this case of the disk, Fig. 7 shows the figure of merit F as a function of traverse spacing on the hypothesis that two crossings over the target constitute discovery. In Fig. 7, in addition, the corresponding figure of merit is shown for the case of a double set of traverses in a criss-cross checkerboard pattern. If two crossings are required to insure discovery, it is clear that the criss-cross flight pattern may be the better. It provides higher values of the figure of merit whenever the traverse spacing exceeds two-thirds of the disk's diameter.

Determination of Flight Pattern: We have considered some chief items which affect the efficiency of search. The following example will show how these items may be adjusted to arrive at the *best* flight pattern. The Basin and Range type of ore distribution will be assumed, together with a minor hypothesis that the ratios of dimensions, namely the shapes of orebodies, are not affected by their absolute size. The dimensions of the orebodies are then also distributed log-normally. Fig. 8 shows this distribution as to length for the Basin and Range orebodies, on the assumption that the lengths are ten times the mean width. The chief feature is the predominance of small orebodies. Half the bodies are less than 220 ft long, and bodies of 40 ft length are the most abundant. They occur 330 times more frequently than those of 2200-ft length. The second curve in this diagram represents the distribution in value of orebodies as a function of their length. Despite the scarcity of large bodies, the maximum values are represented by those of 2200 ft length. These have an individual value of $50 million each, but they occur in the Basin and Range area only at the rate of 1 per 50,000 sq miles. *In toto* they have a value

500 times greater than those in the most numerous 40-ft category. If we further assume that the bodies are randomly oriented and that two traverses across any orebody suffice for its discovery we find that the most ore is discovered per dollar of flight cost when the traverses are spaced 1300 ft apart. This result is depicted in Fig. 9, which shows the effect upon the profit-ratio of varying the traverse spacing. This represents the solution of the problem of finding the best flight pattern under the special conditions postulated.

COMPETITIVE ASPECTS

As I have remarked on a previous occasion, prospecting plans should also "be governed by the practical requirements of competitive prospecting. The company that sees the favorable opportunity early and acts promptly may achieve a major advantage over others that delay too long in improving their analysis of a situation. The competitive aspects of prospecting obviously add another interesting dimension to the range of considerations which should guide the decisions of management about prospecting ventures. One sometimes wonders whether these managers are being paid enough."

SUMMARY

A few of many kinds of statistical data have been mentioned which are needed for guiding geophysical prospecting. Without belittling in the least the importance of improving all the tools for finding ore—geological, geophysical, geochemical—I have urged the primary importance of appraising the *expectations* of finding ore. There is room, I suggest, for improvement in the business of maximizing the returns from prospecting. The vital statistics in prospecting are just as vital to prospectors as are the corresponding vital statistics in the insurance business. Actuarial experts of a new type are needed to compile the necessary information and to appraise the risks in prospecting blind. We need to improve the art of comparing prospecting ventures in terms of the odds—in just one word, in terms of *numbers*.

As a student I recall a colorful professor who used to admonish his class with the famous dictum of Pythagoras: "The nature of things consists in Numbers." I have never been able to understand these mystic words, but I suppose that our modern million-dollar computing machines would be very pleasing to Pythagoras. When suitably interpreted, his dictum probably contains much wisdom. For future prospectors who will search boldly and rationally for all-important giant orebodies concealed in vast areas, perhaps he has furnished a suitable motto—*The nature of things consists in numbers.*

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APPENDIX

Formulas referred to or utilized in text

The Log-Normal Distribution: The normal or Gaussian error function,

$$\phi(u)du = (2\pi)^{-1/2}\sigma^{-1}\exp[-1/2\,\sigma^{-2}(u-u_o)^2]du$$

expresses the probability $\phi(u)du$ that a reading u in the range u, $u + du$ will be obtained. The mean reading and most probable reading is u_o; the parameter σ which determines the sharpness of the peak of the error function is called the standard deviation. If $u = \log_{10} V$, so $du = 0.4343\ V^{-1}dV$, then substitution in Eq. 1 yields

$$\phi(u)du = p(V)dV = 0.4343(2\pi)^{-1/2}\sigma^{-1}\exp$$

$$[-1/2\sigma^2(\log V - \log V_o)]V^{-1}dV$$

This is a so-called log-normal distribution. In Fig. 2,

$$\sigma = 1.53, \log V_o = 4.3$$

If the value V is proportional to the cube of the major dimension of an orebody

$$V = \alpha\, l^3,$$

then the distribution in respect to the length l is also log-normal, and the standard deviation is 1/3 that of the associated distribution in value, namely, 0.51 for the case of the Basin and Range example. In the distribution shown in Fig. 8, the constant $\alpha = 5.23 \times 10^{-8}$. This corresponds to a value $1.00 per cu ft, and to long, prolate, ellipsoidal targets with length to width ratio 10. The value of log l_o is then 2.21.

Detection of Long Needle-like Targets in a Horizontal Plane by a Set of Parallel Traverse Lines

Length of target = l, traverse spacing = s. Let $l/s = r$.

Case No. 1: Long targets randomly oriented in azimuth in a horizontal plane. The respective probabilities that the target will be crossed n times, p_n, or at least n times $p_{n,}$, are

when $(n-1) \leq r \leq n$, $n = 1, 2, 3, \ldots$.

$$p_n = 2\pi^{-1}[\{r^2 - (n-1)^2\}^{1/2} - (n-1)\cos^{-1}(n-1)r^{-1}]$$

when $n \leq r$,

$$p_{n,} = 2\pi^{-1}[\{r^2 - (n-1)^2\}^{1/2} - (r^2 - n^2)^{1/2} + n\cos^{-1} nr^{-1} - (n-1)\cos^{-1}(n-1)r^{-1}]$$

Curves for the cases $n = 1$ and $n = 2$ are plotted in Fig. 6.

Case No. 2: Needle-like targets non-randomly oriented. In this case a weighting factor $p(\theta)$ needs to be applied to the probabilities p_n and $p_{n,}$ above. Let the probability of an azimuth angle between θ

and $\theta+d\theta$ be represented by $p(\theta)d\theta$, where $\theta = 0$ represents the direction perpendicular to the traverse lines. Then the probability that precisely n intercepts will occur is

$$p_n = \int_0^{\pi} p(\theta)\, p_n(\theta)\, d\theta$$

and similarly

$$p_{n+} = \int_0^{\pi} p(\theta)\, p_{n+}(\theta)\, d\theta$$

If, for example, $p(\theta) = \frac{2}{\pi}\cos^2\theta$, about 82 pct of the targets are oriented within 45° of the most probable direction. The formulas for p_n, p_{n+} for this case are, for several values of n,

$$p_1 = 8r/3,\ r \leq 1$$

$$p_{1+} = \frac{4}{\pi}\left[\frac{1}{2}\cos^{-1} r^{-1} + \frac{2}{3}r + \frac{1}{6}(r^{-2}-4)(r^2-1)^{1/2}\right],\ 1 \leq r$$

$$p_2 = \frac{4}{\pi}\left[-\frac{1}{2}\cos^{-1} r^{-1} - \frac{1}{6}(r^{-2}-4)(r^2-1)^{1/2}\right],\ 1 \leq r \leq 2$$

$$p_{2+} = \frac{4}{\pi}\left[\cos^{-1} 2r^{-1} - \frac{1}{2}\cos^{-1} r^{-1} + 2r^{-1}(1-4r^{-2})^{1/2} - \frac{1}{2}r^{-1}(1-r^{-2} + \frac{r}{3}[(1-r^{-2})^{1/2}(2+r^{-2}) - (1-4r^{-2})(2+4r^{-2})]\right],\quad 2 \leq r$$

Figures of Merit for Detection Disc Target

In Fig. 7, figures of merit are compared for the detection of a circular disk by a single set and by a double set of orthogonal traverse lines. It is assumed that at least two crossings of the target are necessary for discovery.

d = diameter of target, s = traverse spacing.

Case No. 1: For the single set of traverses, the probabilities of n intercepts ($n = 1, 2, 3, \ldots$.) are

$$p_1 = d/s,\ d \leq s$$

$$p_{1+} = 1,\ d \geq s$$

or in general

$$p_n = 0,\ d \leq s\ (n-1)s,\ n = 2, 3, 4, \ldots.$$

$$p_n = d/s - (n-1),\ (n-1)s \leq d \leq ns$$

$$p_{n+} = 1,\ ns \leq d$$

Case No. 2: For a set of orthogonal traverse lines, the probabilities of n intercepts ($n = 1, 2, 3, \ldots$.) are

$$p_1 = 2\frac{d}{s}\left(1 - \frac{d}{s}\right),\ d \leq s$$

$$p_{1+} = 2\frac{d}{s} - \frac{d^2}{s^2},\ d \leq s$$

$$p_2 = \frac{d^2}{s^2},\ d \leq s$$

when $d \geq s$

$$p_{2+} = 1.$$

The figure of merit as defined in the text is the probability of discovery divided by the direct cost of search pattern employed. This cost is assumed to be proportional simply to its length, so that the cost of a single set of parallel traverses over a given area is

$$C = \frac{K}{s};$$

and for a double, orthogonal, set

$$C = 2\frac{K}{s}$$

where K is a constant factor. Omitting this constant, the respective figures of merit are

$$F_1 = sp_1 \text{ and}$$

$$F_1 = \frac{s}{2}p_1$$

for the single and double set.

In Fig. 7, the graphs represent

(1) solid curve, single set of traverses:

$$F_2 = 0,\ \frac{d}{s} < 1$$

$$F_2 = 1 - \frac{s}{d} = 1 - \left(\frac{d}{s}\right)^{-1},\ 1 \leq \frac{d}{s} \leq 2$$

$$F_2 = \left(\frac{d}{s}\right)^{-1},\ 2 \leq \frac{d}{s}$$

(2) Dotted curve, orthogonal set of traverses:

$$F_2 = \frac{1}{2}\left(\frac{d}{s}\right),\ 0 \leq \frac{d}{s} \leq 1$$

$$F_2 = \frac{1}{2}\left(\frac{d}{s}\right)^{-1},\ 1 \leq \frac{d}{s}$$

Computation of Optimum Traverse Spacing under the Postulated Conditions

For targets of length between l and $l + dl$, let N_D represent the expected number discovered, each of value $V(l)$. The total expected value discovered then may be written

$$V_D = \int_{l_1}^{l_2} N_D(l)\ V\ (l)\ dl$$

It is assumed that $V(l) = \alpha l^3$, and that at least two crossings are required for discovery. If $p(l)dl$ is the probability of the occurrence of a target of length between l and $l + dl$, and $P_2\left(\frac{s}{l}\right)$ the probability of *discovery*, then the formula above may be written

$$V_D = N_o \int_{l_1}^{l_2} P_2\left(\frac{s}{l}\right) p(l)\ \alpha l^3 dl\ ,$$

where N_o is the total number of the orebodies in the specified area of search. The cost of search is assumed to be $C = \frac{K}{s}$ (neglecting overhead and other non-direct costs). Thus the profit ratio $\frac{V_D}{C}$ is

$$\frac{V_D}{C} = \frac{N_o \alpha}{K}\, s \int_{l_1}^{l_2} P_2\left(\frac{s}{l}\right) p(l)\ l^3 dl$$

Within a constant factor, this quantity is plotted in Fig. 9 for the probability distribution $p(l)$ shown in Fig. 8, and for the function $P_2\left(\frac{s}{l}\right)$ shown in Fig. 6.

CHINO *(Continued from page 569)*

being unaware of the overall goal. The physical disability survey for the same area showed that 18 employes were physically able to perform less than 25 pct of total normal duties called for on the job description. Fifteen of the 18 employes in this category also appeared on the accident-prone list, and two of the employes not on the list were in non-hazardous office work. Another 38 were listed as employes with physical conditions which could limit performance at a later date. Of these 38 with potential health problems, 21 were already on the accident-prone list.

As a result of these surveys, a job placement program was developed to study each case individually and eventually place the employe in a job in which he could safely perform 100 pct of the job duties. Company officials believe that if successfully administered, this program will eventually increase the safety, and therefore the productivity, of an estimated 100 employes by at least 50 pct.

The next approach was to determine whether these physical disabilities developed after the employes were hired or whether they existed prior to employment by the company. It should be remembered that these 56 cases under discussion were results of only a part of the total operation studied. It is extremely difficult to determine whether or not a disability existed prior to employment when an employe has been on the payroll for 20 years; however, it was concluded that 40 of these disabled people were hired as such without the knowledge of company officials.

As a result of this research two projects were undertaken at Chino:

1) Pre-employment physical standards were developed which assured the best physical abilities from existing labor markets.
2) The job placement program was enlarged to allow the employment of a limited number of handicapped persons from the labor market, thus making it possible for the company to fulfill an obligation to society.

These projects were originated recently, and not enough time has elapsed for results to be evaluated. Management is satisfied, however, that the company is now hiring employes with better physical capacities than in the past—which in these days of fringe benefits is a necessity—and that the program has increased employe production by matching physical capabilities to job requirements.

SUMMARY

An accident prevention program should be based on the premise that accident prevention is a component of efficiency and that the most productive management efforts are available in the field of supervisory development. If indeed this is not so, then we must look forward to the time when each crew will have two foremen instead of one—one for operations and another for safety.

The day is gone when the mine office manager can afford to eyeball a line of rustlers, motion to the most likely prospect, and sign him up. If an employer is going to be responsible for a man's future medical bills and his life, health, and accident insurance premiums for the next 20 years, then he is going to want the best.

Obviously, someone must employ the less than perfect specimen of worker. This is a moral obligation as well as sound economic practice, provided the employer knows what he is getting and can fit the man to the job, assuring 100 pct productive effort with no harm to the worker's existing disabilities.

Job placement is good business. No one would expect much productive output if the mine manager were placed in a bricklaying job and the bricklayer assigned to top management duties. Yet, to a lesser degree, we practice this in industry today.

If professional managers are to fulfill their function of securing high efficiency from people planning and working together, they need to operate from fundamental principles. They must not get lost in the forest.

ESPERANZA *(Continued from page 566)*

survey, discrepancy will be compensated for by the succeeding survey.

The triangulation net must be established for either vertical or horizontal sections; however, the use of horizontal sections requires no additional work until the maps are received and planimetering is begun. Instead of eventually working with a minimum of 90 48x68-in. sheets of vertical sections and a maximum of 180 sheets for final payment, it is necessary to use only four 34x45-in. topographic sheets for each survey.

Quantities from horizontal sections were checked against quantities from vertical sections made by the contractor's engineers on successive check surveys. The difference between the two methods was 0.3 pct on some 14 million tons of excavation.

Using horizontal sections, two men have completed six months of progress in five working days, devoting about 75 pct of their time to the progress calculations—which include planimetering, checking, and tabulating—and the remaining time to daily routine engineering work.

Planimetering could be accelerated with the use of a rolling disc planimeter which would cover larger areas or blocks. On the other hand, the smaller blocks lend themselves better to limiting the actual progress work to the smallest overall area and consequently minimize the total amount of work.

Duval is also using topographic maps and horizontal sections in designing pioneer benches, as well as haul roads involving both cut and fill, and in estimating stripping quantities. The mill haul road was designed on the topographic maps and fill quantities calculated by use of vertical sections. Subsequently, haul roads to waste dumps and access roads to new areas have been designed on topographic sheets and cut and fill quantities calculated by use of horizontal sections.

Though at first it was somewhat difficult to visualize horizontal sections and procedures, experience and practice have justified their use. The many uses and flexibility, and particularly the saving in time and money, have demonstrated the advantages and practicability of maps prepared by photogrammetry.

THE GRAND ISLE MINE

C. O. LEE, Z. W. BARTLETT, and R. H. FEIERABEND

The Grand Isle sulfur mine is located in the Gulf of Mexico, approximately seven miles off the coast of Grand Isle, Jefferson Parish, La. The deposit is on acreage covered by oil, gas, and mineral leases originally issued in favor of Humble Oil & Refining Co. by the State of Louisiana which were continued, maintained, and redesignated by the U.S. Department of the Interior after passage of the Outer Continental Shelf Lands Act.

The sulfur deposit was discovered in 1949 when Humble Oil & Refining Co. penetrated more than 200 ft of sulfur-bearing limestone in a zone between 1813 and 2075 ft below sea level. In 1954, Humble drilled ten more sulfur prospect holes, eight of which encountered sulfur ore.

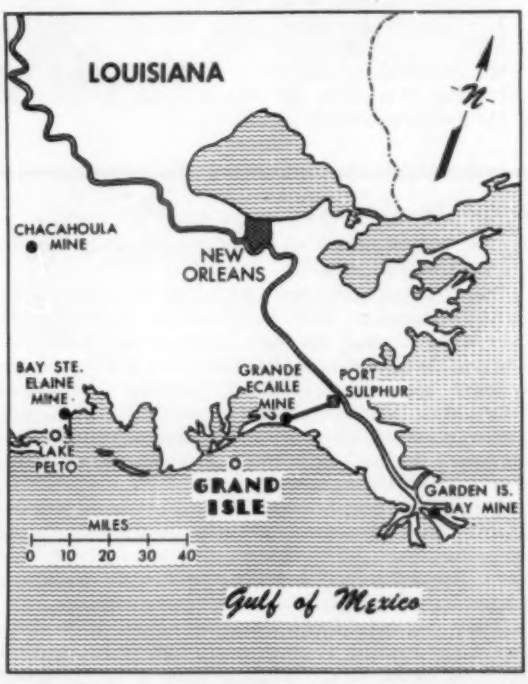
On September 19, 1956, Freeport Sulphur Co. acquired from Humble Oil & Refining Co. the sulfur rights underlying the tracts, and the actual design of the installation began the same month. The first structural contract was awarded in December 1957 and offshore erection began in June 1958. The initial phase of construction has been completed and production by the Frasch process commenced in April 1960. The estimated total cost of the project is $30 million, of which $8 million is the extra cost incurred by the necessity of offshore operations. More than $22 million was expended before production was started.

GEOLOGY OF DEPOSIT

Grand Isle is the third largest sulfur deposit in the U.S. The orebody embraces several hundred acres, but its outer limits are yet to be defined to the northeast, east, and south.

Most Gulf Coast sulfur deposits occur in a caprock mantle of calcite (referred to as limestone), anhydrite, and occasionally gypsum, which covers the apex of an intrusive mass of salt. Commercial quantities of sulfur are usually confined to the calcite or limestone member. Most often such limestone is completely enclosed by dense anhydrite below and impervious sediments above, which effectively form a closed reservoir.

The depth of the Grand Isle orebody ranges from 1800 ft to 2500 ft below sea level. Within the present boundary, the sulfur-bearing limestone varies in thickness from 220 ft to 425 ft, while the sulfur content varies an average of about 15 pct in the leanest hole to an average of about 30 pct in the richest. Rock containing less than 5 pct sulfur is not classed as ore, and holes assaying less than 20,000 long tons per acre of sulfur in place are not considered commercial offshore. The sulfur enrich-



Location map of the Grand Isle mine and other Freeport sulfur mines in the Gulf Coast area of Louisiana. The depth of water at Grand Isle is approximately 50 ft.

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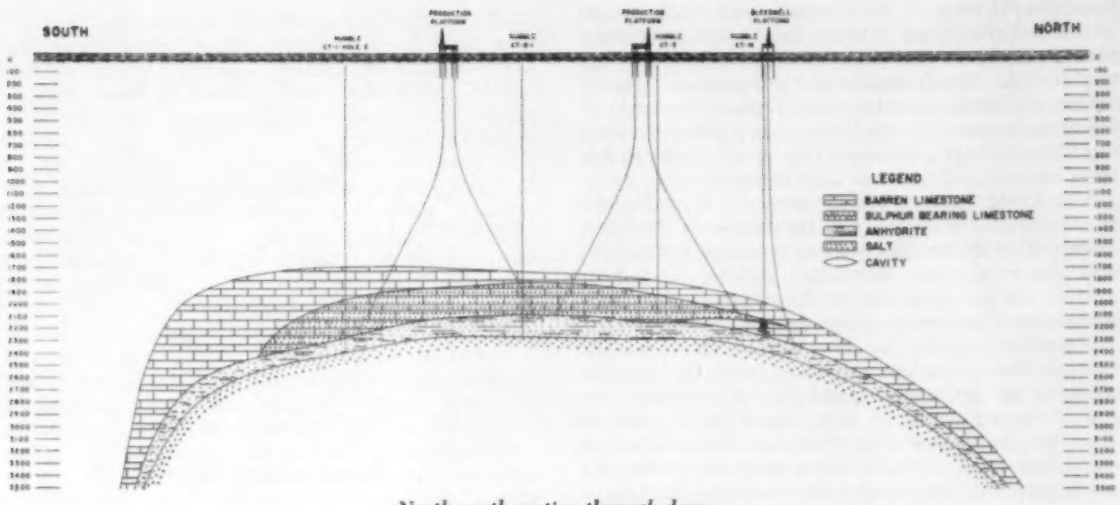


North-south section through dome.

ment is not particularly high, but the thickness of the orebody is substantially greater than other deposits in the Gulf Coast area. Though strictly a geological curiosity, one exploratory well cut 75 ft of low-grade sulfur-bearing rock at 7495 ft below sea level, the deepest occurrence of elemental sulfur yet encountered in the Gulf Coast.

The gangue rock in the sulfur-bearing horizon is typically a blue-gray to black, moderately hard, fine-grained fractured limestone which has been re-cemented by white secondary calcite and sulfur. The rock is dense to vugular, porous, and highly permeable. The sulfur occurs in crystalline masses, in vugs, in disconnected veinlets, and as disseminations throughout the rock. Due to traces of oil occurring within this structure, the sulfur is discolored. The limestone also contains lenses of marl and shale plus minute amounts of gypsum. Several cavities have been found in the sulfur horizon, the largest of which is 18 ft in vertical extent.

The barren, or non-sulfur-bearing, limestone caprock that overlies the sulfur horizon ranges in thickness from 0 to 260 ft, average thickness being about 100 ft. It is permeable, porous to moderately dense, medium gray limestone with white secondary calcite cementing small cracks and fissures.

Anhydrite underlies the sulfur horizon and varies from 29 to 190 ft in thickness. It exhibits the typical saccharoidal texture found in Gulf Coast salt domes. The rock is generally dark gray, hard, and dense with occasional fractures that sometimes contain traces of oil and sulfur. Below the anhydrite, rock salt occurs to an unknown depth.

FRASCH PROCESS

In the Frasch process, the sulfur-bearing formation is pierced by a series of drill holes into which a number of concentric pipes are inserted. Water, heated under pressure to about 325°F, is injected into these wells and forced into the ore zone. As the hot water percolates through the formation, it gradually gives up its heat to the rock. When the temperature of the sulfur and the enclosing rock exceeds 240°F, the sulfur melts, separates from the rock, and flows downward by gravity through the heated channels to the bottom of the well—the site of water injection. Here the sulfur separates from the incoming water, for the specific gravity of sulfur is approximately twice that of water. After a pool or reservoir of liquid sulfur accumulates at the well bottom, the sulfur rises in one of the concentric pipes and is brought to the surface by means of an air lift.

The limestone caprock, saturated with water and enclosed by impervious formations, constitutes an equivalent of a pressure vessel. For the purpose of avoiding a buildup in pressure, a volume of water equal to the volume injected must be withdrawn. To accomplish this task and yet not withdraw the heated water (which tends to rise to the upper portions of the dome), additional wells are drilled along the deeper flanks of the dome to withdraw the heavier cold water which accumulates there.

GENERAL DESCRIPTION OF FACILITIES

The basic facilities for the Frasch process are the same whether onshore or in the Gulf of Mexico. However, three major design problems made the Grand Isle venture unique:

1) The 50-ft water depth at the mine location and the extremes of weather in the Gulf imposed special problems in the design and construction of foundations.

2) Historically, the Frasch industry has been dependent on fresh water in large quantity. Since the nearest unlimited source of fresh water—the Mississippi River—is 25 miles away, some means had to be found to mitigate this need.

3) A safe, reliable, all-weather system was needed to get the sulfur inshore for storage.

The consideration of these factors and the solutions to the problems they provoked are reflected in the physical plant layout of the mine. The major units of the Grand Isle installation are set on steel-pile-supported platforms raised 60 ft above the water and connected by a series of 200-ft-long bridges. As shown in the drawing above, the final

layout will form a Y, oriented east-west. Large individual platforms support the steam-generating plant, warehouse and shop, the drilling and production station, bleedwater wells and disposal system, offices, and living quarters. Small platforms or towers serve as piers for the bridge spans which connect the various large platforms. One small platform has been constructed to serve as a heliport.

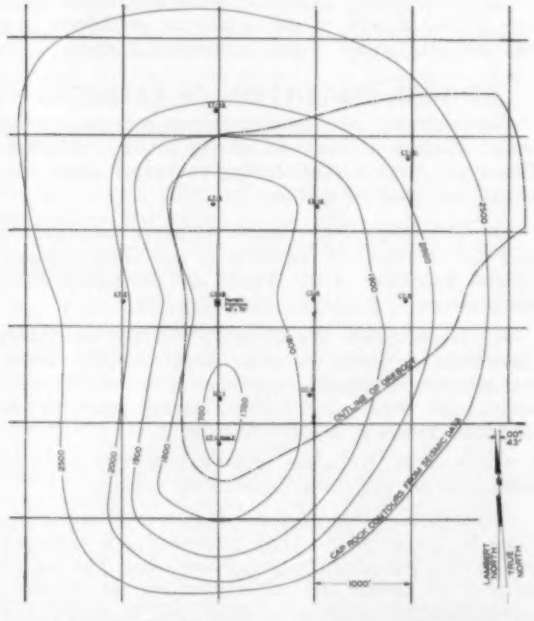
The bridge spans, 200 ft long, 15 ft wide, and 15 ft deep, are supported by four-pile 50x50-ft towers. The 12-ft wide roadway on top of the bridges was designed for a seven-ton moving load, permitting the use of rubber-tired equipment for transportation of personnel and materials.

Pipelines, located on the bottom chord of the bridges, carry heated seawater from the heating plant to the production platform for injection into the producing wells. In turn, liquid sulfur and air from the wells flow to a control station located on the lower deck of the drilling platform. After the air is released, the liquid sulfur is pumped through a heated, submerged, high-pressure pipeline seven miles to shore. Onshore the sulfur is loaded into insulated barges and towed 25 miles to Freeport's central storage and distribution point at Port Sulphur for shipment to customers.

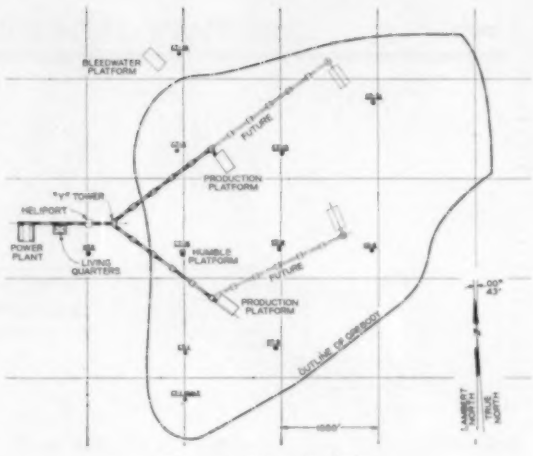
STRUCTURAL DESIGN FEATURES

The major factors which controlled structural design included: wind forces, wave forces, foundation conditions, subsidence, and corrosion.

Winds, Waves: Line squalls cause occasional short-lived winds of 50 to 90 mph, but huricane winds which have velocities above 75 mph are the greatest hazard. Since 1893, three hurricanes have passed directly over the site of the Grand Isle mine. Eight additional hurricanes with winds from 100 to 128 miles per hour have passed within 30 to 160 miles of the mine site since 1916. Hurricane "Audrey" of June 27, 1957, passed 125 miles west of the site and



Location of Humble's prospect holes and outline of the orebody. The depth contours are on top of the caprock.



Plan of mining facilities.

in its path, wind velocities of 105 mph were recorded with gusts up to 140 mph. Consulting meteorologists have predicted that winds of 120 mph will occur at the mine site at an average frequency of once each 100 years, and sustained winds of 100 mph will occur once each 10 years.

Meteorological and oceanographic analyses indicate that 105 mph winds will generate a breaking wave with a crest at an elevation about 45 ft above the Mean Gulf Level (MGL) at the mine site. In addition, studies show that this condition is likely to occur at an average frequency of once each 20 to 30 years. At the crest of the maximum wave, 45 ft above MGL, calculations indicate that the force on the piling is 1375 lb per sq ft. Wave damage to structures in the path of hurricane "Audrey" tended to confirm these predictions.

For design purposes, a wind force of 50 lb per sq ft, which can be exerted by sustained winds of 110 to 115 mph, plus wave forces which can be generated by a 43-ft breaking wave, were selected. Combining these live forces with known dead loads, all structures were designed in accordance with the AISC code, which allows maximum stress in steel of 27,000 psi for combined live and dead loads.

Foundation Conditions: Eight soil borings were made at the mine, seven to a depth of 250 ft below MGL and one to a depth of 200 ft. Below the Gulf floor they penetrated from 168 to 185 ft of soft to medium stiff clays, which overly 20 to 36 ft of very dense sand.

While the deeper sand stratum under the Gulf floor shows excellent bearing capacity and would permit a minimum of piles, the number used was not determined by their supporting strength alone. Other important points to consider were framing of the deck structure, underwater bracing, and particularly, the bending stresses induced above and below the submerged bracing by horizontal wind and wave forces. Pile size and penetration were determined in laboratory from boring samples; 30-in. OD steel pipe piles proved to be the economical design and required a minimum of bracing in the zone exposed to storm wave forces.

Subsidence: At most sulfur mines which employ the Frasch process, the removal of the sulfur weakens the host rock sufficiently to cause it to collapse. Since the overlying sediments offer little resistance, the surface ultimately subsides.

Many factors determine the size and shape of the subsidence basin at the surface: the volume and rate of sulfur removal; character of the overburden; depth, thickness, and areal extent of the mine workings; and the time elapsed since mining started. Observations made at Freeport's Grande Ecaille and Garden Island Bay mines indicate that, in this area of the Gulf Coast, the average angle of failure of sediments between the surface and the orebody is about 50°, and the volume of surface subsidence is about 1.25 times the volume of the sulfur removed.

Calculations indicate that after depletion of the Grand Isle deposit, vertical surface subsidence of 43 to 45 ft will have occurred above the center of the orebody. Such subsidence will form an elliptical-shaped basin that will extend outward from the center for a distance of 3500 to 5500 ft. Due to this settling of the surface, the first two production platforms will subside approximately 25 ft. Similarly, the living quarters will settle 5 ft and the heating plant, about 3 ft.

In addition, the vertical settlement is accompanied by horizontal creep of shallow sediments toward the center of the basin. Structures on the slopes of the basin are expected to be displaced horizontally about the same amount that they settle.

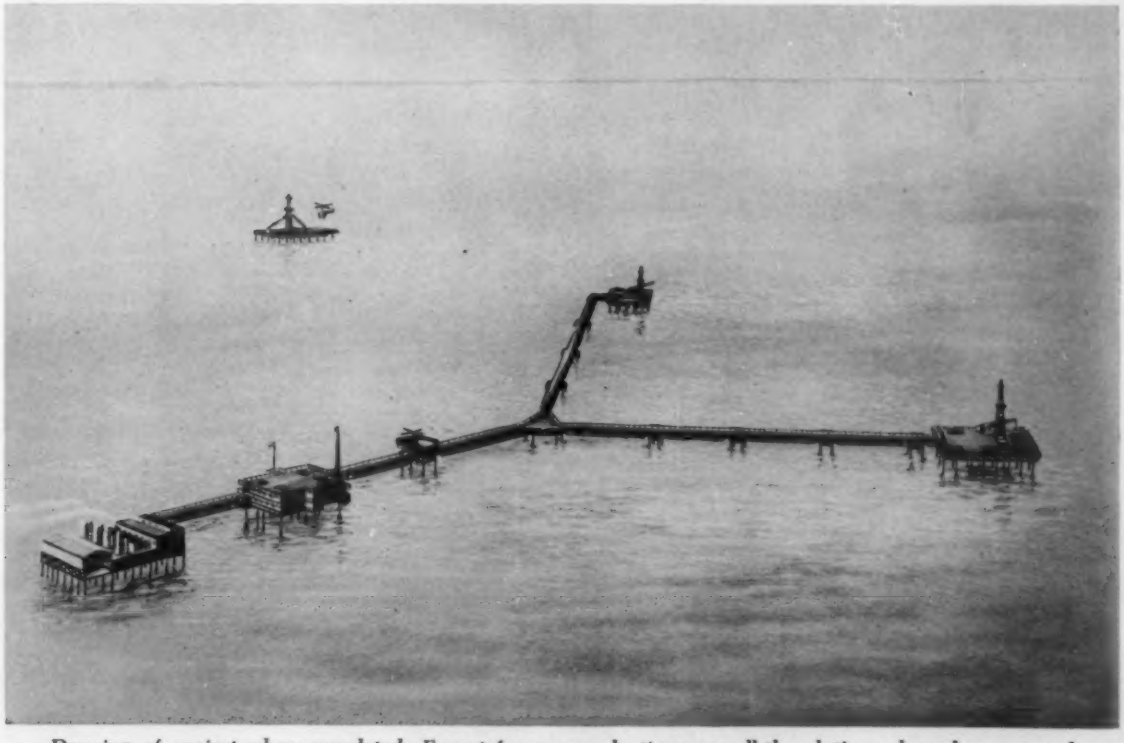
To provide for such vertical and horizontal movement, special plans were made. The production platforms will be salvaged and reconstructed at their original elevations after 10 to 15 ft of settling has occurred. Because the bridge piers are subject to considerable subsidence, the tower legs were constructed so as to permit the bridges to be jacked up and levelled whenever necessary. The bridges are long enough to permit 3 ft of differential horizontal movement between towers. The power plant and living quarters are within the anticipated subsidence basin but are near the edge of the basin where subsidence should be less severe. To have located them outside the basin would have added substantially to the cost of construction. Extra structural members were required on all installations to withstand stresses induced by differential horizontal movement of the shallow sediments.

Corrosion: Steel structures located offshore are subjected to three different corrosion environments: the totally submerged zone, the splash zone immediately above and below the water line, and the salt-air zone above the splash zone.

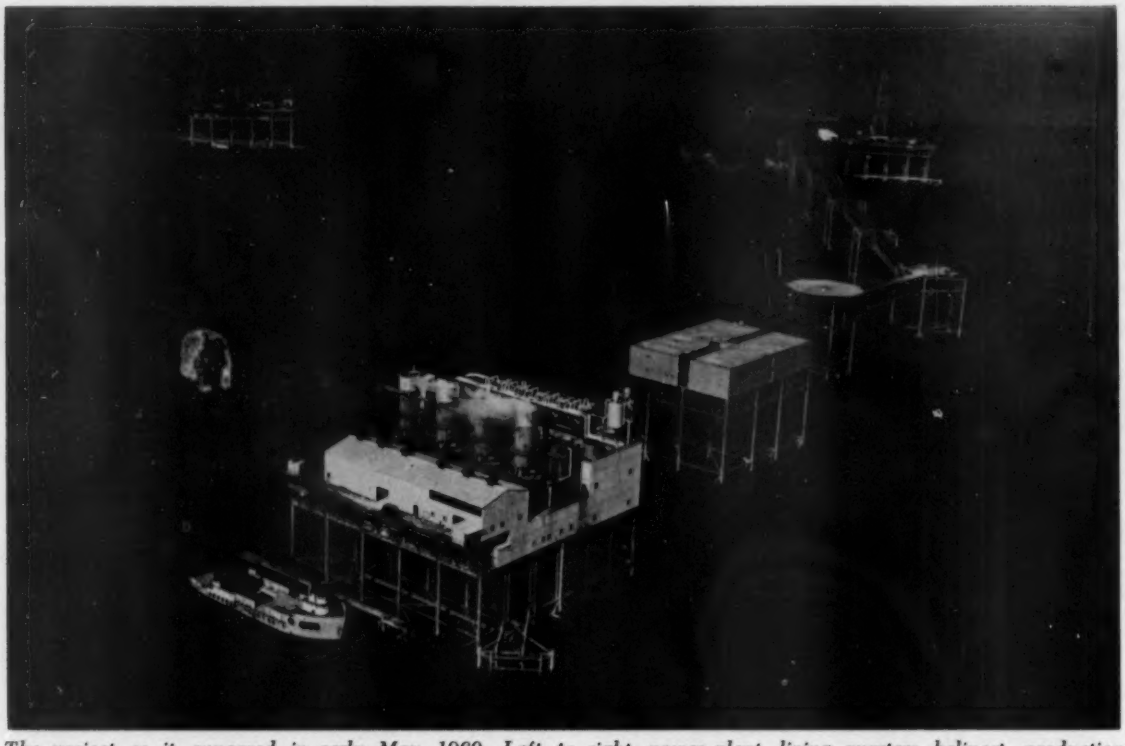
In the totally submerged zone, cathodic protection has proven to be a very simple and effective method. With a source of alternating current available, only a rectifier and properly spaced, buried graphite anodes are required.

In the splash zone, a 10-ft range from 2 ft below to 8 ft above water, the steel surfaces are alternately wet and dry. In this changing environment, cathodic protection fails to function and protective coatings are almost impossible to maintain. Rather than fight corrosion, it was decided to add sufficient metal thickness to provide a safe structural section for 30 years. At the observed corrosion rate of 0.025 in. per year, this meant adding ¾-in. extra steel in the splash zone. Actually, ⅞-in. structural plate containing 0.2 pct copper was rolled and welded as a protective jacket outside the structure leg. Where considerable subsidence is expected, the thickness of the double plate is somewhat less because, as the structure sinks, the leg enters the cathodic protection zone.

An inorganic zinc silicate was chosen as the protective coating in both the splash and the salt-air zones after investigations revealed its performance



Drawing of project when completed. Except for one production arm, all the platforms have been erected.



The project as it appeared in early May, 1960. Left to right: power plant, living quarters, heliport, production platform. Bleedwater platform (upper left) is operated from main installation by remote control.

for periods up to seven years without failures on various oil company structures in the Gulf. The coating comprises a reactive silicate liquid and a finely divided zinc powder that are mixed together before application. The surface must be blasted to "white metal" using an abrasive that will produce an anchor pattern of from 0.5-1.5 mils. This is necessary because the optimum thickness of the coating is 2.5 mils. After air drying for one to two hours, the coating is cured by spray saturation with a special solution which forms a chemical bond between the coating and the steel in addition to the mechanical bond. The coating is ready for service twenty-four hours after application of the curing solution. Its physical properties are outstanding: it has excellent abrasion and impact resistance; it is unaffected after prolonged weathering in marine atmosphere; and it is resistant to burn-back during welding. This last property was particularly important, for it permitted individual members of the structure to be sandblasted and coated before fabrication. Approximately 870,000 sq ft of steel were coated at a cost of $0.50 per sq ft.

Crane setting the Y tower deck section on piles driven through and cut off just above the template legs.

BASIC STRUCTURES

The structures which support the installations are composed of three elements: template, piling, and deck section. The construction method employed and described below is the standard method used for permanent offshore oil platforms.

The template, 80 pct of which is below the surface of the water, serves two purposes: it provides a pattern spacer and guide for driving the piling which actually supports the structure, and it acts as underwater bracing for the piles against lateral forces imposed by winds and waves. The vertical members of the template are 34-in. OD pipe; the cross bracings, 12-in. OD pipe. The templates were positioned accurately by transit and levelled by weighting the high side. When in the proper position, the 34-in. diam template legs extended approximately 10 ft above sea level. The template weight was supported temporarily on the mud bottom by timber mats at each corner.

Once the template was in position, a 30-in. OD pipe pile was inserted through each 34-in. leg and driven 170 ft into the subsoil. After the piles were driven to "refusal" in the sand stratum below the Gulf floor, the tops of the template legs and piles were welded together and the annulus grouted.

Thus, the weight of the structure is transferred to the piling and the template becomes underwater bracing for the piling. The piles were cut off at a convenient predetermined elevation above the template legs and then made ready to receive the third element—the deck section.

The prefabricated deck sections were installed by inserting the deck section legs into the open-end piles, after which the legs were welded to the piles. The three elements—template, piling, and deck section—are thus joined into a single unit.

Some 10,000 tons of steel and pipe have been used to date. Over 38,000 ft of 30-in. diam pipe have been used in piling and supporting legs as well as 40,000 sq ft of grating and more than 1,000,000 bd ft of creosoted lumber.

The large templates and deck sections were fabricated onshore and carried by barge to the construction site. Some of the largest lifts in the history of construction were made for emplacing these structures. The template for the production and bleedwell platforms measured 200 ft long, 106 ft wide, and 75 ft high. Weighing 450 tons, it was set in a single piece by using two 250-ton cranes. The power plant deck, made in two sections weighing 650 tons each, took the contractor only seven hours to place atop piles cut off 50 ft above the water level.

Rental on such heavy marine equipment approaches $20,000 per day and its use is subject, of course, to all the vagaries of wind and weather. However, only one day was lost due to bad weather conditions during the entire offshore erection period, which totaled 59 working days.

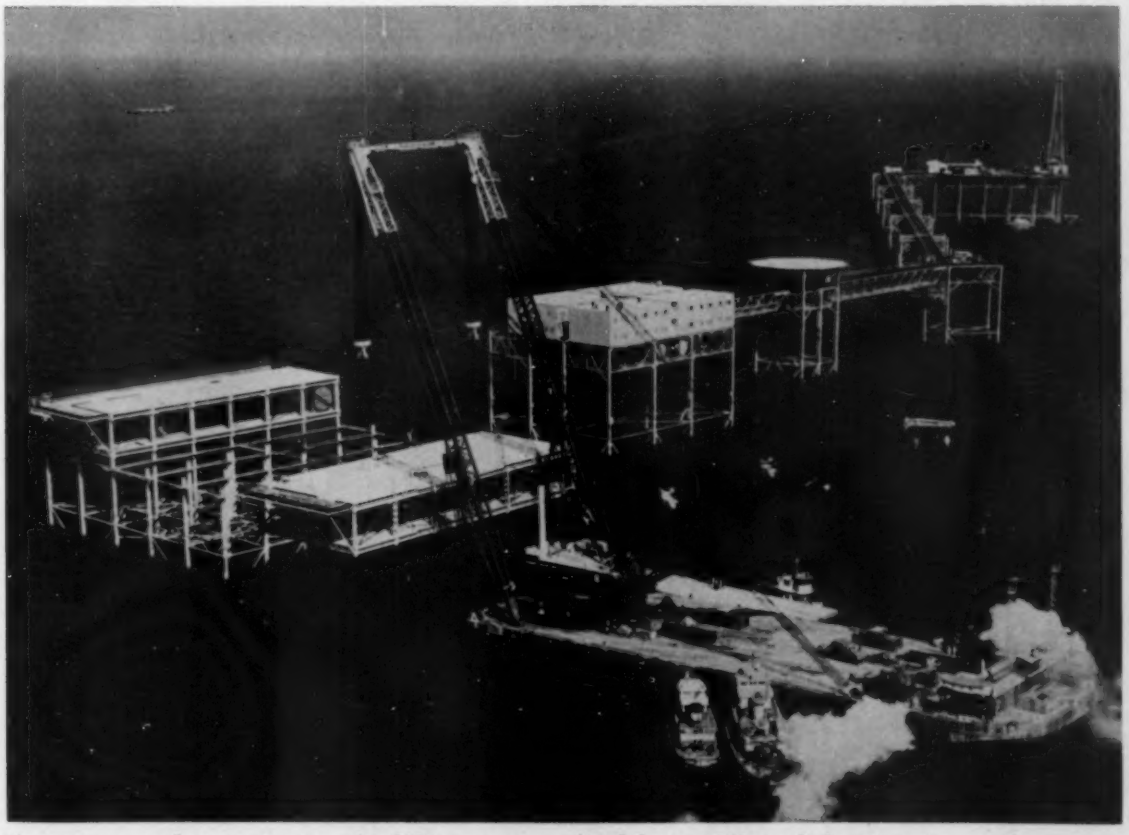
HEATING PLANT

The heating plant, the third largest Frasch plant in the world, is designed to deliver an average of 5,000,000 gal of 325°F water per day with a maximum capacity exceeding 5,500,000 gal daily. Under average operating conditions it will burn 13,000,000 cu ft of natural gas daily, produce 360,000 lb of steam per hour at 600 psig and 600°F, generate 4500 kw at 2400 volts, and compress 2500 cfm of air to 1000 psig. Plant efficiency at full load is expected to be 93.5 pct, a 6.5 pct loss attributed to radiation and stack losses. The heating process and plant are designed to operate efficiently with water of any salinity ranging from fresh water to concentrated brine solutions.

Seawater Process: It was apparent many years ago that the development of future sources of sulfur located in tidewater areas near or in the Gulf of Mexico would be virtually impossible unless the dependence on a large source of fresh water were overcome. Freeport spent eight years of research on the problem of heating salt water, a project which culminated in 1952 in the construction of the Bay Ste. Elaine plant—the first and only commercially successful plant to heat salt water for the Frasch process. The basic seawater-heating process was described in an earlier article.*

Seawater, averaging about 75°F, is sprayed into the top of preheater towers and percolates downward through two beds of ceramic rings. In the up-

* "Development and Operation of Sulphur Deposits In The Louisiana Marshes" by Bartlett, Lee, and Feierabend. MINING ENGINEERING, August 1952.



View of power plant construction. An 800-ton crane emplaced the two 650-ton deck sections in seven hours.

per bed the water temperature is raised to 140°F by upward-flowing stack gases from the boilers; in the lower bed the water temperature is increased to 190°F by heat supplied from six specially designed air-gas pre-mix burners located beneath the lower bed of packing. After leaving the tower the water is picked up by high pressure centrifugal pumps and forced through 20 tubular heat exchangers. It leaves the heat exchangers at 325°F and 400 psig, which is sufficient pressure to force it into the sulfur wells. Steam is supplied to the heat exchangers from turbines which exhaust at 50 to 100 psig. The exhaust steam is supplemented whenever necessary by additional steam from a makeup station.

The condensate is returned to the boilers in a closed system. A small quantity of condensate may be lost and two single-stage flash evaporators are provided to produce up to 40 gallons per minute each of distilled water from the 190°F seawater circuit. Total capacity of the evaporators is 11 pct of maximum feedwater flow. Should conditions warrant, fresh water in this small quantity can be processed through the evaporators.

Description of Equipment: The heating plant platform measures 180 ft long by 175 ft wide. It is composed of two decks, the lower of which is at an elevation 55 ft above MGL and the upper deck, 75 ft above MGL. The pump room and water-treating facilities occupy the lower floor; the top deck is the main operating level. A building houses the generators, air compressors, chemical storage, operating controls, a warehouse, and machine shop. Boilers and preheaters are also located on the top deck but are not housed. The 20 tubular heat-exchangers are located on the roof of the generator-compressor building.

Four Riley Type RX-15 pressurized furnace water-wall boilers, each having a capacity of 90,000 lb of steam per hour, are provided. The steam is generated at a pressure of 600 psig and a temperature of 600°F is attained by super heating. The boilers are designed for natural gas firing only.

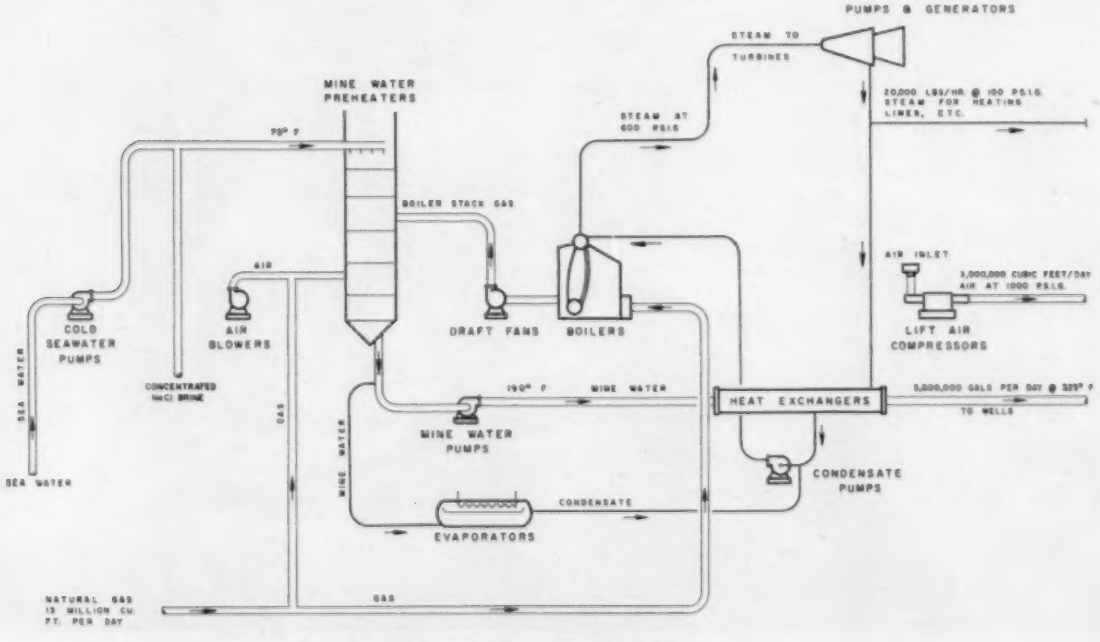
A mine water preheater tower of Freeport's own design is provided for each boiler. The preheaters stand 60 ft high and are 12 ft in diam. Each is packed with two beds of ceramic rings and is equipped with six North American, 7,000,000 Btu-per-hr burners to supply the additional heat to raise the water from 140°F to 190°F.

There are 27 items of turbine-driven equipment including three full size boiler feed pumps, four induced draft fans, four mine water pumps, and three deepwell-type seawater pumps. These turbines develop from 300 to 500 hp each, use 600 lb of 600°F throttle steam and exhaust at 50 psig.

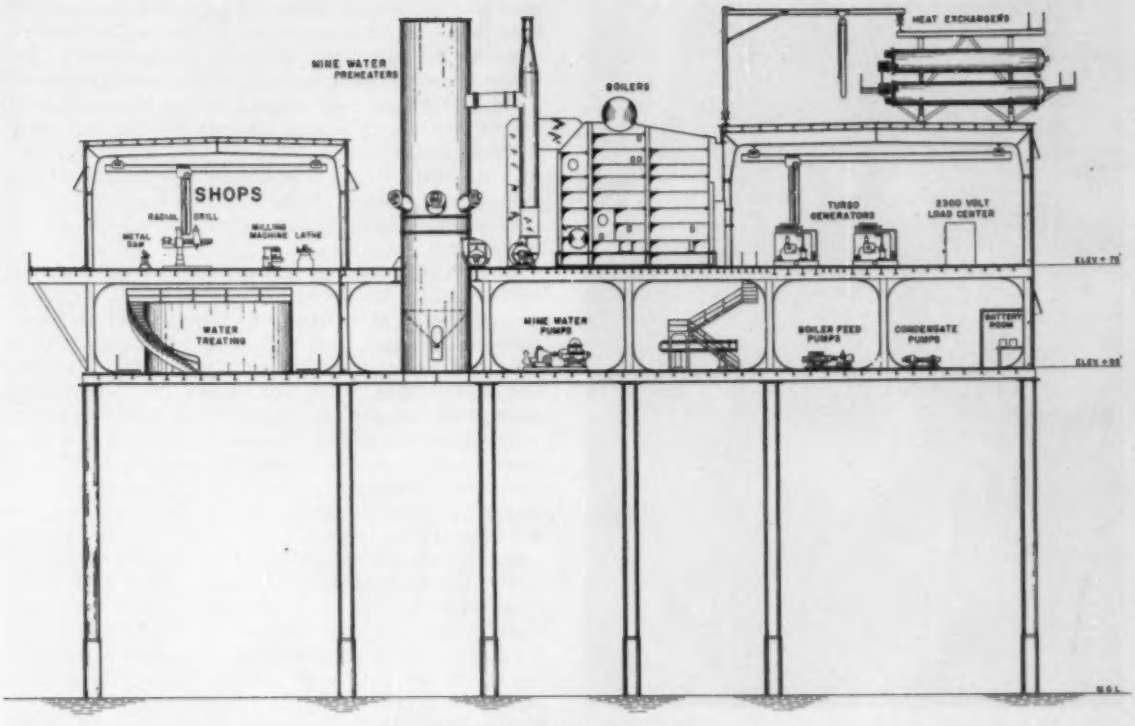
Electrical power generating capacity is 5300 kw. There are three EMC 1500 kw steam turbine-driven geared generators. Seven-stage Worthington turbines operate at 5500 rpm and the generators, with direct-connected exciter, at 1200 rpm. These turbines exhaust at 100 psig with one uncontrolled extraction point after the third stage. The uncontrolled extraction, at approximately 190 psig and 30 pct throttle flow at full turbine load, is used for feedwater heating.

In addition, for standby and startup, there is a 1000-hp Clark TA gas turbine which drives an 800-kw Elliot generator. Gases from the turbine exhaust to the furnace of one of the boilers to supply preheated combustion air. Full load exhaust from the gas turbine will supply enough hot combustion air to support approximately 75 pct boiler load; the power generated by the turbine represents virtually a byproduct.

Three Clark CMA-4 motor-driven compressors, specially balanced to prevent vibration, are provided. These units are rated at 830 cfm of free air at 1000-psig discharge pressure and each is driven by a 350-hp synchronous motor. Vibration-free performance is essential on the platform since, in effect, the equipment is 120 ft above the ground.



Flow diagram of heating plant.



Section through heating plant.

Water-treating equipment includes two continuous-flow water softeners, each 13 ft high with a 26-ft diam, equipped with dry chemical feeders. These units treat a concentrated brine solution for use in modifying the chemical composition of the seawater. Chemical feeding equipment is provided to supply oxygen-scavenging chemical to the preheated water.

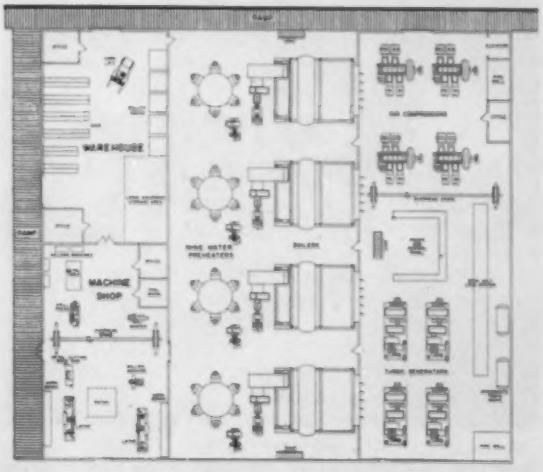
A complete instrument and control system is provided to permit one operator to control and monitor the operations of all major equipment. These controls include complete combustion control equipment for all boilers, temperature and pressure regulators, and pump controls and a complete annunciator system to detect off-normal conditions. Four men plus a laboratory technician will operate the power plant.

DRILLING AND PRODUCING FACILITIES

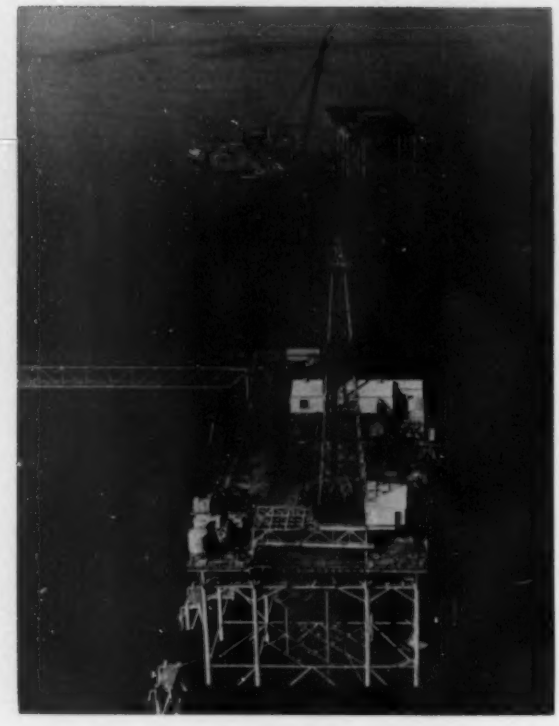
The Frasch process requires simultaneous operation or *steaming* of a number of wells. It is impossible to predict how long any well will operate satisfactorily and how much it will produce. Therefore, to allow the capacity of the heating plant to be utilized at all times, wells must be drilled and equipped in advance of their actual need for production. At Grand Isle the wells are directionally drilled from a multi-well platform; thus the wellheads are concentrated in a small area while the bottom hole locations can be widely scattered.

Freeport directionally drilled sulfur wells as far back as 1944 at Hoskins Mound. Over the past few years directionally drilled sulfur wells have become routine at Bay Ste. Elaine and at Chacahoula. Although cost of deflected holes rises rapidly with depth and horizontal deviation, at Grand Isle where all wells will have a true vertical depth of approximately 2200 ft, horizontal deviation amounting to as much as 1250 ft from the surface location is expected to prove economical. Maximum angle of drift will be about 55° from the vertical and maximum buildup of drift angle will be 5° per 100 ft of depth. Table I shows the data for the first ten production wells.

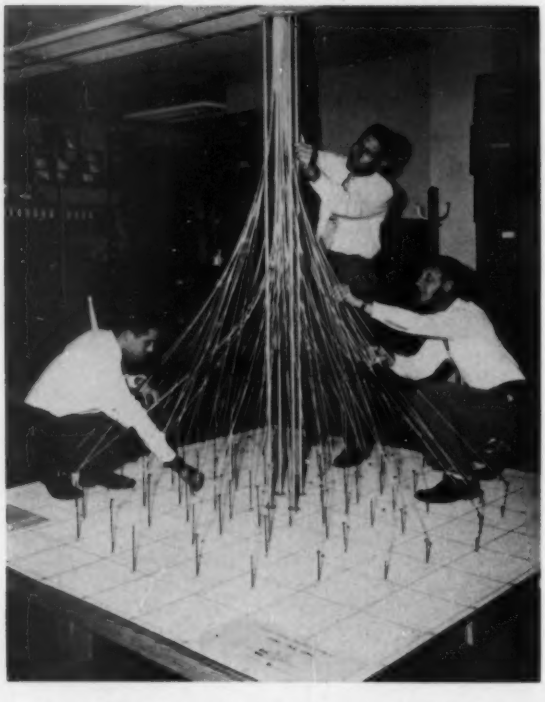
Each production platform will have openings to permit drilling from 36 surface locations on 11-ft centers. No more than 12 of these wells, however, will be in use at any one time. After a producing well has been depleted of sulfur, the pipe will be salvaged and the bottom portion of the well will be plugged and abandoned. The salvaged conductor



Plan view of top deck of heating plant.



Production platform (foreground) is 1000 ft from the bleedwater platform, which is shown under construction.



Scale model showing plan for directional drilling from a production platform. Each rod represents one well.

pipe and surface casing will be re-used and another hole will be sidetracked in a different direction. Each of the 36 surface locations will be used three times, permitting the drilling of 108 wells from each platform. Bottom hole spacing will be approximately 175 ft. Because the area drained by any one well is quite limited, it is expected that four platforms may be required to give complete coverage of the dome. Furthermore, each platform will be rebuilt and relocated one or more times during the life of the mine.

Drilling-Production Platforms: About three-fourths of the top deck, which measures 116x224 ft, is occupied by the drilling machinery and its auxiliary equipment. The remaining area contains a change room for crews, a tool house, a pipe threader, and pipe storage racks. The center bay of the lower deck contains the operating or producing sulfur wellheads and piping. The drilling mud system—pumps, shale shaker, desander, and mud pits—is along one side of the platform. The relay or well control station is on the lower deck beneath the pipe reworking shop.

Light-duty oil-field drilling equipment is used. A conventional derrick, 129 ft high with a 24-ft base, is mounted on a double substructure. One sub-base can be moved longitudinally along the platform while the other sub-base can be moved at right angles to the length of the platform. The derrick and machinery can thus be moved easily and quickly to any location on the platform. The 300-hp Model F-30-D Ideco double-drum draw-works, capable of drilling to 5000 ft, is permanently mounted on the derrick floor. The pipe racks can be located on either side of the derrick which precludes the necessity of turning the derrick around when it is used near the end of the platform. The 16-in. blowout preventer is under the derrick floor on the top deck of the platform.

Drilling mud from the well returns through permanently installed troughs in the main derrick substructure and beneath the platform floor. A 300-hp 8x14-in. mud pump and a 150-hp 6x12-in. stand-by unit are provided. Mud storage capacity totals 750 bbl in two tanks. Centrifugal pumps are used for the purposes of mixing, transferring, supercharging, desanding, etc.

Two American 30-ton capacity, pedestal-mounted, diesel-powered cranes handle pipe and materials between barges and platforms in addition to doing other work on the top deck, such as changing air-lines in producing wells.

All drilling equipment is powered by electricity generated in the heating plant. Personnel safety, elimination of the fire hazard inherent in internal combustion engine fuels, lower operating cost, and greater reliability led to this selection of power sources. A-c power is supplied through a 2300-v cable to the platform where it is converted to d.c. by motor generator sets—a 450-hp, 2300-v, a-c motor driving two 300-hp d-c generators. All d-c generators and motors are interchangeable. Speed of the traction-type d-c motors is controlled through variable excitation on the generator field. The driller operates all major pieces of equipment through a control panel mounted on the drawworks.

The casing program is designed for safety and for ease in reworking and re-use. The 24-in. conductor pipe is driven to "refusal" and braced into the structure immediately above the water line; 400 to 600 ft

of 16-in. surface casing is then set and cemented, below which deflection of the borehole begins. Ultimately, 13⅜-in. casing is set and cemented at the 1500-ft level. Other equipment is sized according to the water injection rates and the sulfur-air return rates.

In reworking a well, as much water liner and sulfur line as possible will be recovered before permanent abandonment plugs are set. Attempts will then be made to remove at least 100 ft of the pipe below the 13⅜-in. casing in order to have clean open hole exposed in the sediments above the cap-rock for a new deflection.

Control Stations: Sulfur mines onshore usually have long surface pipelines connecting each well with the control station. At the Grand Isle mine the control station is located on the same platform that contains the well-heads and therefore only short surface lines are necessary. Hot water to individual wells is piped through a header system and down each side of the center bay of the platform. Takeoffs for each well incorporate water metering and controlling devices. Water flow rates are adjusted in the control room by means of remote motor-operated valves, and the volume is recorded by orifice meters. Similarly, liquid sulfur from each well is piped along the sides of the center bay into one of two 40-ton capacity collecting tanks and then pumped to shore installations.

SULFUR STORAGE AND TRANSPORTATION

Sulfur produced from the Grand Isle mine moves through the same storage and loading installations at Port Sulphur which are now used by two of Freeport's other mines—Grande Ecaille and Garden Island Bay. Liquid sulfur is barged to Port Sulphur from these two mines, respectively 10 and 50 miles away, and unloaded into storage tanks. Similar plans have been made for production from the Lake Pelto mine, now under development 80 miles from Port Sulphur.

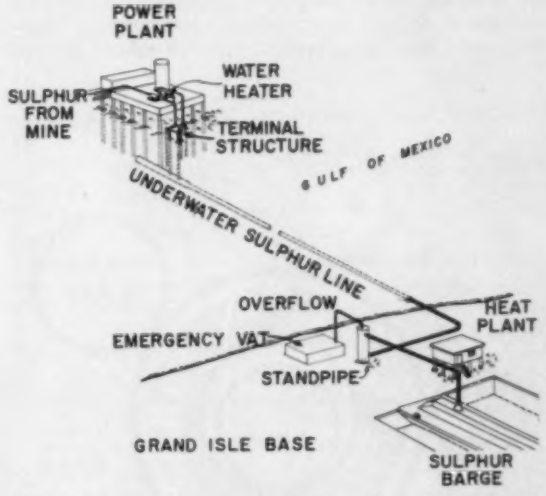
Some of the sulfur is transferred from the tanks for liquid shipment to customers, but most of it is pumped to vats and allowed to solidify in huge blocks or bins which serve as bulk storage. For ultimate shipment to consumers, the blocks are broken down by power shovels and bulldozers, and the solid sulfur is conveyed by belt to railroads or to barges and ships in the Mississippi River.

The transportation of sulfur from the Grand Isle mine is complicated by the effects of weather at the exposed location as well as the impracticability and high cost of erecting sulfur storage and loading facilities at the mine site. Detailed studies of various means for transporting the Grand Isle sulfur to Port Sulphur included: 1) the pumping of liquid sulfur through a pipeline to Port Sulphur, 2) the pumping of a sulfur-water slurry to Port Sulphur where the sulfur would be reclaimed, 3) use of an aerial tramway to Grand Isle, and 4) the use of liquid sulfur barges and self-propelled sulfur tankers of various capacities. These studies indicated that the most economical, reliable, all-weather means of getting the sulfur to Port Sulphur is by pipeline from the mine site to Grand Isle, La., and then by liquid tank barges from Grand Isle to Port Sulphur.

Table I. Production Well at Grand Isle Mine

Well Number	Depth		Horizontal Deflection	
	Measured Depth Along Borehole, Ft	True Vertical Depth, Ft	Distance Of Well Bottom from Surface Location, Ft	Maximum Angle from Vertical
1	2583	2189	859	48° 30′
2	2588	2241	773	42° 45′
3	2662	2284	806	42° 00′
4	2740	2290	950	45° 45′
5	2686	2261	970	44° 30′
6	2862	2331	1063	52° 30′
7	2637	2139	1069	50° 30′
8	2330	2012	683	45° 00′
9	2436	2089	764	43° 45′
10	2544	2020	1062	56° 45′

Underwater Pipeline: The pipeline, extending approximately seven miles from the power plant at the mine to a barge-loading wharf situated inshore at Grand Isle, La., will be buried about 5 ft below Gulf bottom. It will consist of three pipes: a 14-in. OD protective casing, a 7⅝-in. OD hot water jacket line, and a 6-in. OD sulfur line. Liquid sulfur is pumped through the 6-in. pipe while hot water is pumped through the annulus between the 6-in. and the 7⅝-in. pipes. The annulus between the 7⅝-in. and 14-in. pipes provides space for a 2¼-in. thickness of thermal insulation and a small air gap. The weight of the 6-in. and 7⅝-in. pipes is carried by ball-bearing rollers spaced approximately every 19 ft along the line. The rollers afford a means of pushing or pulling the inner lines through the 7-mile-long, 14-in. casing and allow virtually frictionless differential movement between the two sets of lines.

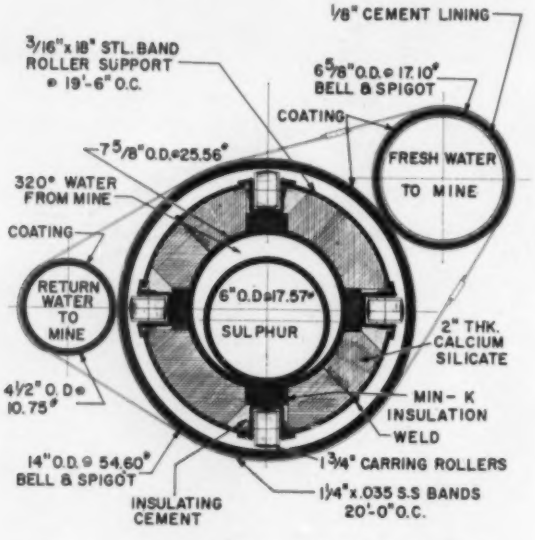


Schematic diagram of the offshore transportation system employed to carry the sulfur from mine to barges.

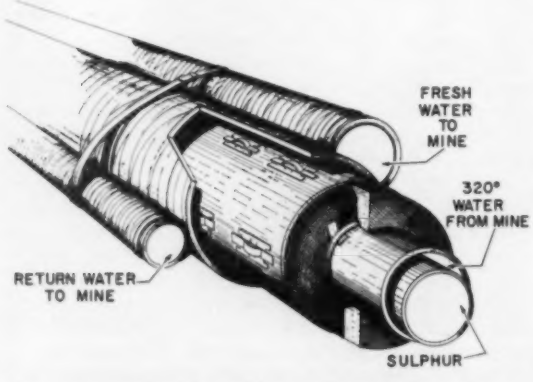
The entrance temperature of both the sulfur and water at the mine end of the pipe is about 320°F and the exit temperature on the shore end is about 280°F. A sulfur entrance temperature higher than 320°F is precluded because the viscosity of sulfur at such higher temperatures becomes excessive. Similarly, an exit temperature less than 280°F is undesirable because it is too close to the freezing temperature of sulfur. The efficiency of the insulation and the air gap which surrounds the 7⅝-in. pipe is high. It is calculated that with an average ambient soil temperature of 75°F, the 14-in. casing has reached about 110°F and that the heat loss to the wet soil amounts to 90 Btu per linear foot per hour, or about 75,000,000 Btu per day.

Maximum capacity of the pipeline is 4500 long tons of sulfur per day or 470 gpm, which requires a pump pressure of about 900 psig on the mine end. At this rate of sulfur flow, only 15 gpm of 320°F water is required to assist in overcoming the heat loss. At 2500 tons per day or 250 gpm sulfur flow, about 25 gpm of water is needed. For both starting up and when at extremely low sulfur rates, the water rate may reach 100 gpm, which will require a water pressure of 1400 psig at the plant end. At the shore end, the liquid sulfur flows directly into insulated tank barges, which are then towed over an inshore route 25 miles to Port Sulphur. The water from the 7⅝-in. line is cooled from 280°F to atmospheric temperature and returned through a 4½-in. OD line to the mine for reheating and re-use through the pipeline. To prevent corrosion and scale deposition within the 7⅝-in. pipe, the water must be of extremely high quality. As shown in the accompanying drawings, the 4½-in. return line is strapped to the outside of the 14-in. casing.

A 6⅝-in. OD pipeline, also strapped to the outside of the 14-in. casing, serves two purposes; it provides additional supporting surface for the pipeline in the very soft clay and, secondly, it affords a limited source of fresh water for the mine. Water from the Mississippi River is transported as ballast in the barges returning from Port Sulphur and then pumped to the mine through this line. The quantity of fresh water is sufficient only for use as domestic water and general service water at the mine. Since this water is not deaerated, the dissolved oxygen makes it slightly corrosive; for this reason, the line is protected inside by a coating of cement.



Cross section of offshore sulfur line at rollers.



Cutaway perspective of the offshore sulfur pipeline.

A unique feature of the pipeline is the method of overcoming the thermal stresses. The inner lines would normally expand about 55 ft when heated from 75°F to the 300°F operating temperature. Expansion joints or loops are the usual means of providing for this expansion but in a buried line, they may not be effective and their cost would be excessive. By eliminating all expansion joints, the construction of the line was immensely simplified. This task was accomplished by anchoring the pipeline in such a manner as to prevent the 55-ft expansion movement. In doing so, however, the stress imposed on the pipe walls exceeds the yield strength of ordinary steel. The inner lines were therefore constructed of a high tensile steel having a yield strength of about 60,000 psi. The stress in the 14-in. casing is much less than in the hot lines and grade X-42 steel having a 42,000 psi yield strength is used.

Prior to its burial, the outer casing was placed in 10,000 psi tension by exerting a pull on each end of the casing and the ends fixed to anchor structures. This tensile stress was relieved when the casing reached its operating temperature of 110°F.

Before the inner lines were placed in operation, they were heated to 225°F and allowed to expand approximately 30 ft. While in this expanded state, the ends of the lines were permanently fastened to the outer casing. Thus all lines were tied together, and their movement was prevented due to the secure anchoring of the outer casing.

As the inner lines were heated from 225°F to their operating temperature of 300°F and their further expansion restricted, a compressive thermal stress developed. The combined stresses in the two inner lines at operating temperature is calculated to be approximately 60 pct of their yield strength. If the inner lines cool down below 225°F, the thermal stress will reverse into tension. At atmospheric temperature, the combined stresses will amount to about 70 pct of their yield strength. Longitudinal movement of the pipelines is thus confined and precludes the necessity of expansion joints.

The need for the anchor structures is only temporary. When the soil becomes remolded around the pipeline, the soil resistance will be sufficient to prevent appreciable movement, particularly on the shore end where it is buried in two miles of fine sand. At the mine end, however, the line is buried in a very soft clay, which will yield slightly to the pipeline stresses and allow a small amount of longitudinal movement.

Pipeline sections of 2000-ft lengths, complete in all details, were pre-assembled on the shore. To assure full-strength welds, special welding techniques were developed for the high-tensile pipe, and all welds were radiographically inspected and hydrostatically tested. Supported by a 16-in. diam "buoy" pipe fastened to a cluster of lines, the entire pipeline was pulled from the shore to the mine site, 2000 ft at a time, until all pipeline sections were connected and emplaced in a previously dug trench

on the ocean bottom. Fathometric survey of the line after completion of this stage of construction showed the pipeline to be well within the tolerances for curvature and sag. Details of the design features, welding, and testing procedures, plus construction and fabrication problems have appeared previously in print.*

About two weeks were required to expand the lines, tie them off, and raise the unit to operating temperature. Actual temperature and pressure drops and heat losses from the system have varied only minutely from the design calculations.

BLEEDWATER DISPOSAL

Pressure tests made on the dome prior to commencement of operations indicated little, if any, water leakage from the caprock to the enclosing sediments. This necessitates the withdrawal of 5 million gallons of cold waste water per day from the dome to prevent a "pressure-vessel" effect. It was originally estimated that eight to ten bleedwells, directionally drilled with bottom hole spacing of 150 to 200 ft, would be required to remove this volume of waste water. After further testing, however, the formation was proven to be more permeable than expected. In addition, the specific gravity of the connate water was substantially less than anticipated due to lower chloride (salt) content, a 15° higher formation temperature than previously expected, and the presence of dissolved gases (such as CO_2) which are released as the water rises to the surface, thus providing a liftting effect. These characteristics reduced to six the number of bleedwells required for adequate waste water removal and precluded the necessity of pumping equipment.

The bleedwells were drilled from a satellite platform—similar to the production platform but not connected to the main installation—located on the northwest flank of the dome. The exact site of the bleedwell platform was selected when it was determined that 1) the formation in this area was cavernous, and 2) the platform would be outside the orebody limits, thus minimizing the effects of subsidence on the well casings.

The waste water has a pH of 6.6 and, except for the chloride content (70,000 mg:l) and hydrogen sulfide content (1500 to 2000 mg:1), it is similar to seawater. Hydrogen sulfide, the only harmful constituent of the bleedwater, stays in solution as the bleedwater flows directly from the wells to dilution mixers or pumps submerged 15 ft below the surface of the Gulf. The mixers dilute the bleedwater in the ratio of 150 parts of seawater to 1 part of well water. Hydrogen sulfide readily combines with the oxygen of the seawater to form harmless sulfates; the oxygen content of the diluted mixture is sufficient to reduce the hydrogen sulfide to 0.2 mg:l. Further dilution and aeration of bleedwater occurs when it is subjected to the current, winds, and waves. So effective is this disposal system that only the faintest odor of hydrogen sulfide can be detected. Widespread sampling of the waters around the platform show that the hydrogen sulfide, for all practical purposes, is completely dissipated at a distance of 100 to 150 ft from the mixers. Close observation during a period of several months has shown this operation to have no adverse effect whatever on the marine life.

The pre-assembled, 2000-ft long pipeline sections lie on fabrication racks prior to their emplacement in the Gulf. Two 8-yd clamshell dredges are shown digging the trench to the mine site visible in the distance.

The waste water system is remotely operated from the production station through multi-conductor marine cables which supply power and system controls. Dilution pumps, system valves, etc., are operated by pushbutton. Adequate overload safety devices are designed into the system as are other safety devices to prevent dumping large volumes of waste water without proper dilution. Signal control lights allow the operator at the production station to quickly observe operating conditions on the bleedwater platform.

AUXILIARY FACILITIES

Warehouse, Shops: The warehouse for storage and handling of operating materials, supplies, and emergency spare parts is on the west end of the heating plant platform, and it occupies an area 45x65 ft.

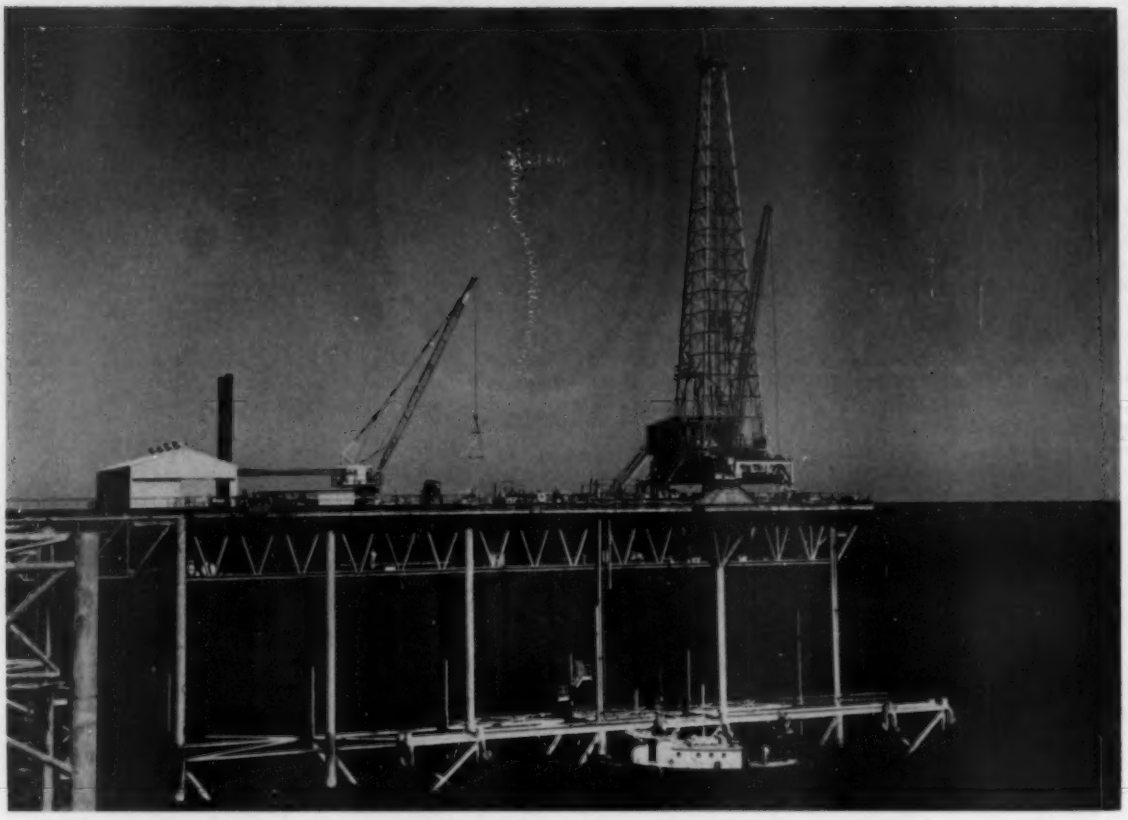
The 45x85-ft machine and maintenance shop is adjacent to the warehouse. Outfitted with the most commonly used heavy machine tools, it should be possible to do all preventive maintenance, routine repairs, and most emergency work on the equipment at the mine. Major equipment repairs will be handled in Freeport's Grande Ecaille shops or in various contract shops in the New Orleans area. On the lower deck beneath the maintenance shop is a small electric and meter repair shop.

Regular freight deliveries are made by company-owned marine equipment. Moorings for supply vessels are provided at the heating plant platform, the drilling-producing platform, and the bleedwell platform. Pedestal-mounted, 30-ton capacity, diesel-powered cranes are provided at each of these locations for unloading the barges, and fork-lift trucks are used to handle material and pipe on the platforms and bridges.

Communication System: Freeport was among the first industrial companies in the Gulf Coast area to use microwave radio-phone for interplant communication. The 6575-megacycle automatic system is now

* C. M. Cockrell: The Grand Isle Sulphur Mine Heating Plant and Underwater Sulphur Line Design. *ASME Paper No. 59-A-183*, Nov. 1959.

C. M. Cockrell and J. M. Shilstone: Design, Welding Procedure and Fabrication of Concentric Molten Sulphur Pipeline. *Welding Journal*, April, 1960, pp. 334 et seq.



Side view of the drilling rig on production platform.

interconnected with the commercial telephone system so that by dialing his telephone any man in any plant can talk with any other plant, shop, warehouse, or office. Each property has its own automatic dial telephone system. The microwave system is supplemented by a VHF 152.87-megacycle short-wave radio-phone system, used primarily by the marine department for its widespread operations. Both systems have been expanded to include the Grand Isle mine. One microwave channel between Grand Isle mine and the New Orleans office is used for data transmission via transceivers. All warehouse, time, and operating data, etc., are processed through the company's IBM 650 installation in New Orleans.

PERSONNEL REQUIREMENTS

About 150 employes will be required to operate the mine and the sulfur transportation system. Of these, 125 will work at the mine but only one-half of them will be stationed at the mine at any one time. Additional personnel under the supervision of the centralized operating offices at Port Sulphur and New Orleans will perform engineering functions, laboratory work, special staff and maintenance work. Normally, the mine operates 24 hr per day, seven days a week. Operating employes work five consecutive 12-hr days while living at the mine, after which they are away from camp for five days. Employes assigned to maintenance work have a somewhat different schedule.

The employees are transported via 7-passenger Sikorsky S-55 helicopters over the seven miles of water to and from a landing base at Grand Isle, La. From there to his home, the employe furnishes his own transportation. With a rotating schedule, 25 men can be changed each day during the daylight hours with ease. Oil companies that have operated many years offshore have found helicopters to be safer and more dependable than boat transportation, although not necessarily more economical.

A two-story, air-conditioned steel structure located near the heating plant houses employes at the mine. Built at a cost of $1,375,000 (including structure) the building contains 60 double bedrooms, 30 bathrooms, two television rooms, a large recreation room, a kitchen and cafeteria, a first-aid room, and offices. The net cost of operating the living quarters approximates $7 per man per day.

Employe safety was one of the prime considerations in the design of facilities and selection of equipment. In addition, a complete first-aid station is maintained with a trained medical man on continuous duty.

Special hurricane precautions, similar to those in use at other mines of the company on the Louisiana coast, are taken at this mine. A meteorological consultant retained by the company supplies daily weather bulletins to each of our operating mines. During the hurricane season special weather bulletins are issued on all tropical storms. When a storm in the Gulf of Mexico or Caribbean Sea moves toward the Gulf Coast, the Grand Isle mine, as well as other Freeport mines, goes on a storm alert. Contact is maintained with other off-shore operators and all caution will be exercised to close down operations and evacuate all personnel from the structure in ample time to reach safer areas.

STATUS OF GEOCHEMICAL PROSPECTING IN THE USSR

by HERBERT E. HAWKES

The importance of geochemistry to Russian plans of greater mineral productivity is assuming major proportions. The author provides a résumé of their organization and progress.

In March 1956 a conference on geochemical methods of prospecting for ore deposits was held in Moscow. This conference was the culmination of a ten-year period of extremely rapid increase in both research and routine application of geochemical prospecting methods in the USSR. This activity was divided among groups centered in extremely widely separated bases of operation, ranging from Moscow and Leningrad in the West, Yerevan in the Caucasus, and Alma-Ata in Central Asia to Chita near the Manchurian frontier in the Far-East. The All-Union Conference on Geochemical Methods of Prospecting for Ore Deposits, as the meeting was called, was the first opportunity for these scientists from many parts of the country to meet and exchange experiences. It also served to introduce members of the different research laboratories located in the city of Moscow itself, where adequate channels of technical communication had not yet been established.

As a result of the Conference, it was resolved that a concerted effort should be made for the participants to publish the results of their work. Two books have appeared as a direct response to this resolution. I. I. Ginzburg prepared a synthesis of the field of geochemical prospecting for minerals based on the material presented at the Conference.[1] This volume has been translated into English and is now available. In addition, the individual papers presented at the Conference were assembled into a symposium volume and published in 1957 under the editorship of V. I. Krasnikov.[2] Unless otherwise noted, these two books have supplied the source material for the present appraisal of the status of geochemical prospecting in the USSR. It is thus about four to five years old. In the years following the conference, the literature has carried a substantial volume of technical papers, together with a few monographs pertaining to specialized aspects of geochemical prospecting.

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ORGANIZATIONS

The two major groups within which most Russian geochemical prospecting activity is carried out are the Academy of Sciences and the Ministry of Geology and Conservation of Resources. In general, the Academy of Sciences has the responsibility of research on basic principles, whereas the Ministry of Geology is assigned the task of applied research and production. In practice, the division of duties between these two groups is not at all well defined, and overlapping activity and other failures in communication apparently are common phenomena.

The individual organizations within the Academy of Sciences and the Ministry of Geology that are known to have taken an active part in developing or applying geochemical prospecting methods are listed in Table I. Each one of these organizations has a very considerable degree of autonomy, which adds to the difficulty in coordinating the research work.

In addition to the activities of the various branches of the Academy of Sciences and the Ministry of Geology, a considerable amount of work is done in local autonomous academies of sciences and in universities, also listed in the same table.

METALLOMETRIC SURVEYS

Metallometric surveying, or prospecting based on the systematic sampling and trace analysis of soil or weathered rock, has been applied on a very broad scale by the various regional geophysical

Table I. Organizations Engaged in Geochemical Prospecting

Academy of Sciences, U.S.S.R. (AN SSSR)
- Chukhrov Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Moscow (IGEM)
- Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements, Moscow (IMGRE)
- Vernadskii Institute of Geochemistry and Analytical Chemistry, Moscow (GEOKHI)

Ministry of Geology and Conservation of Resources (MGiON)
- All-Union Aerogeological Trust, Moscow (VAGT)
- All-Union Geological-Scientific Research Institute, Leningrad (VSEGEI)
- All-Union Scientific Research Institute of Exploration Geophysics (VIRG)
- All-Union Scientific Research Institute of Hydrogeology and Engineering Geology, Moscow (VSEGINGEO)
- All-Union Scientific Research Institute of Methods and Procedures of Exploration, Leningrad (VITR)
- All-Union Scientific Research Institute of Mineral Raw Materials, Moscow (VIMS)
- Main Geophysical Organization (Glavgeofizika): includes regional geophysical trusts for carrying out routine survey work.

Universities
- Leningrad Technological Institute
- Leningrad State University
- Moscow State University
- Tomsk Polytechnical Institute

Union Republic Academies of Sciences
- Armenian Academy of Sciences, Yarevan
- Kazakh Academy of Sciences, Alma-Ata

trusts working under the direction of the Main Geophysical Organization (Glavgeofizika) of the Ministry of Geology. The following discussion is based largely on the data presented at the Conference by Shirokov and Kovaleva.[3]

Metallometric surveying is normally conducted concurrently with routine geophysical work. Samples are collected at regularly spaced intervals along profile lines. Where a large area is to be covered, samples are more widely spaced than in detailed surveys, as indicated in Table II. In arid regions, samples are taken either from the surface or from a depth not exceeding 20 cm. In areas of forest or alkaline soils, samples are taken at depths of 40 cm or more. Samples consist of about 50 g of whatever material is encountered at the point designated. One sampling crew, consisting of a chief sampler and two helpers, can collect 5000 to 6000 samples per month.

Samples are sieved to — 0.5 mm and then pulverized to — 0.1 mm. With mechanical grinding equipment, production is 500 samples per shift. Samples prepared in this way are submitted to field spectrographic laboratories for determination of a check list of 15 elements (Cu, Pb, Zn, Co, Ni, Mo, W, Sn, Bi, P, F, V, Mn, Hg, As). With two to three shifts working on each spectrograph, a monthly productivity of 15,000 samples per instrument can be maintained. Toward the end of 1955, the Main Geophysical Organization was operating 85 field spectrographic units on this basis.

Spectrographic determinations are plotted on geologic base maps and contoured. Where a coincidence of geophysical, geochemical, and other indications suggests a favorable site for detailed exploration, drillholes are put down. Only after the bed-rock ore has been located do the geophysical groups turn the information over to the geological organizations for further development.

Metallometric surveying has been applied most extensively in the desert climates of Central Asia, where the emphasis has been on exploration for large copper and base-metal deposits. As of 1955, a total of 172,000 sq km had been covered by systematic metallometric surveying (Table III). In the same year, the "application of metallometric surveying was made mandatory in geological surveying and exploration on any scale by all geological organizations of the USSR".[4] Although it is difficult to know specifically what is meant by this statement, in general it certainly implies an increase in activity, as indicated in Table IV.

The success of metallometric surveying in actually finding new ore deposits must be judged on the basis of the increasing scale of operations, plus the published claims of the Russian authors. As an example, the following statement is quoted directly from the paper presented at the Conference by Shirokov and Kovaleva:[3]

> Several examples follow, which affirm the high effectiveness of metallometric investigations in various regions.
>
> 1. In the Transbaikal region, in the Alekzavod district, the Bugdain molybdenum deposit was discovered with the aid of metallometry in 1953, where prospecting-surveying work had been conducted earlier on a scale of 1:50,000.
>
> 2. In the region of Malyi Khingan in 1954-1955, the Bidzhan tin deposit and a number of other small tin ore deposits, overlooked during the heavy mineral surveying conducted here earlier, were revealed by metallometric surveys.
>
> 3. In the Kurbin iron-ore region of the Buryat-Mongolian ASSR, the operations of geophysical organizations were slanted exclusively as late as 1954 toward the detection of new deposits of iron ores and therefore were limited to magnetic prospecting methods. In 1954, the application of metallometric surveying in this region over relatively small areas led to the discovery of the Malan molybdenum deposit which is now being prospected by the Irkhutsk Geological Administration.
>
> 4. In the Atasui iron ore district we succeeded, with the aid of metallometry, in establishing a polymetallic mineralization of a horizon of siliceous limestones, occurring below the basic iron ore and manganese ore horizon. The economic value of the polymetallic mineralization is now being studied by the Karaganda Geological Administration.
>
> In central Kazakhstan in the last three years, geophysical expeditions found and reported to geological-exploratory organizations more than 50 deposits and ore manifestations of nonferrous and rare metals of which 40 were exposed by metallometric surveys in areas investigated earlier by geological methods on scales varying from 1:200,000 to 1:100,000.

The conduct of metallometric surveying in the USSR has been severely criticized in the Soviet literature because of the poor integration with geological survey work. It is felt that the routine, blind

Table II. Scales of Metallometric Surveys[3]

Types of Surveys	Scale of Survey	Average Distance between Traverses (Profiles) in Kilometers	Distance between Sample Points in Meters	Density of Sample Points per Km²
Reconnaissance	1 : 1 000 000	10	100	1
	1 : 500 000	5	100	2
	1 : 200 000	2	100 to 50	5 to 10
Standard Prospecting	1 : 100 000	1	100 to 50	10 to 20
	1 : 50 000	0.5	50	40
	1 : 25 000	0.25	50 to 20	80 to 200
Detailed Prospecting	1 : 10 000	0.1	20	500
	1 : 5000	0.05	20 to 10	1000 to 2000
	1 : 2000	0.02	10	5000
	1 : 1000	0.01	5	20 000

Table III. Coverage by Metallometric Surveying as of 1955 by Ministry of Geology, USSR[3]

District	Area in Km²	District	Area in Km²
Central Kazakh	80,000	Primorie	10,000
Altai	6,000	Khabarovsk	8,000
Zailiiskii Alatau	8,000	Kuznetskii Alatau	
Karatau	10,000	Altai	15,000
Central Asia (other)	5,000	Salair	
Transbaikal	30,000	Buryat Mongol A.S.S.R	

Table IV. Scale of Metallometric Surveys by Ministry of Geology[4]

Year	Samples, No.	Year	Samples, No.
1948	67,000	1953	3,063,000
1949	238,000	1954	4,680,000
1950	778,000	1955	4,955,000
1951	2,325,000	1956	6,155,000
1952	2,673,000	1957	6,722,000

application of a set prospecting formula can lead to serious misinterpretation and the missing of important geochemical data. This weakness in the metallometric system of prospecting is also its strength, as by cutting back on the need for the high-priced and scarce talents of professional geochemists it has been possible to keep the cost of metallometric surveying at a very low level. In 1955 the average cost per sample, including collecting, analysis, plotting, and interpreting, was slightly less than 4 rubles, equivalent to approximately 40¢ in purchasing power.

RESEARCH AND DEVELOPMENT

Metallometric surveying is the only geochemical method of prospecting that had been applied on a routine basis at the time of the 1956 Conference. However, a considerable volume of experimental work has been carried out on many other geochemical methods. These include several pilot-plant field surveys of substantial size, each involving more than 5000 samples. Since much of this developmental work was considered to be very successful, it is a virtual certainty that the new methods will soon be, if they are not already, applied on a routine basis.

Much of the research by Soviet scientists has led to the same conclusions as were reached almost completely independently in Western countries. Their success with metallometric surveying is paralleled by Western success with similar techniqes in the eastern United States and in Central Africa. Their observations on geochemical provinces and on primary geochemical dispersion patterns are not far different from ours. Their geobotanical studies led them to the discovery of an indicator plant for copper in Central Asia. They have worked on the dispersion of heavy metals and of copper in both stream water and in stream sediments as a method of mineral reconnaissance.

In some respects, Western geochemical techniques are well ahead of the Soviet developments in spite of the much smaller scale of the Western research effort. Outstanding in this respect is the use of extremely simple colorimetric tests for readily soluble copper and zinc in stream sediment as a reconnaissance method. Mention should also be made of techniques that are specially adapted for prospecting glaciated terrane, such as sampling soil from spring and seepage areas and the tracing of dispersion patterns in peat bogs over buried ores. Western analytical instruments in general appear to be superior to their Russian counterparts.

In some fields, Soviet research and development has resulted in techniques that represent either a distinct improvement over ours or that are entirely unfamiliar to the Western exploration profession.

Methods of prospecting for borates based on plant studies have been developed. The boron content of vegetation has been correlated with the boron content of buried saline deposits. At the same time, certain plant symptoms associated with excesses of boron have been described. Instruments for field determination of the boron content of samples by means of neutron absorption have been applied successfully in prospecting.

The readily soluble molybdenum content of soil has been studied as an indication of molybdenum-rich sulfide deposits. It is claimed that this is a measure of the molybdenum content of soil moisture and hence of deeply buried molybdenum-bearing deposits.

The gaseous dispersion patterns of mercury formed by the migration of mercury vapor in soil air have been studied in relation to deposits buried by a considerable thickness of post-ore cover. This method is suggested not only as a method of prospecting for mercury deposits but also for mercury-rich base and precious metal deposits. Spectrographic techniques with a detection limit of 0.3 ppm Hg are described.

Reconnaissance based on the dispersion of the mobile uranyl, sulfate, and molybdate ions in ground and surface water has been the object of especially intensive study. According to one statement by Vinogradov,[5] systematic determination of the uranium content of water was used as the primary method of reconnaissance in uranium exploration. The conditions controlling the mobility of sulfate and molybdate have been studied at some length in the laboratory. In the field, experimental surveys of the sulfate and molybdenum content of natural water have been made in the vicinity of a large number of molybdenum-rich sulfide deposits with encouraging results.

CONCLUSIONS

Geochemical prospecting in Russia and in the West has evolved independently with almost no mutual contact between the two groups of investigators. Many of the developments in the two camps are parallel. In some respects, Western methods are more advanced than the Russian and in some, the reverse is the case. The principal difference is in the scale of operations. In 1956, which is the date of the most recent full report on geochemical prospecting activity in the Soviet Union, the volume of Russian work in both experimental and applied fields of geochemical prospecting was probably between five and ten times the effort of all Western nations combined.

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.....but what can I do?

How can the mineral industry attract young men into the career of a mineral engineer? This question was one of several discussed at the Education Symposium during the AIME Annual Meeting last February and excerpts of this discussion appeared in the May issue of MINING ENGINEERING. Our self-appraisal was both enlightening and constructive, and perhaps it may lead ultimately to the goal of *prestige plus glamour* for the profession of mineral industry engineering.

If we are to draw qualified high school students of today into our industry as its engineers of tomorrow, we as individuals cannot sit on our hands and expect the appeal of mining to develop by itself. Each of us should be willing to offer his services in an attempt to interest qualified students in the challenge, variety, and rewards of our profession.

This is all well and good, but what can I do? To be frank, there are many things which each of us can do. Individually, in groups, or through local sections of the Society of Mining Engineers, we can volunteer our services and experience to local schools which may desire advisors for student science and engineering groups. Likewise, we may offer our services as advisors or speakers to local boys' clubs, the Boy Scouts, or to other similar organizations.

Any individual may rightly feel that, by himself, his effectiveness as a salesman for our industry might be limited. Similarly, some local sections of the Society of Mining Engineers may find it difficult to maintain a desirable type of continuing program to stimulate interest in our profession. As in most cases, a successful sales program must be planned and it must have variety. To assist members of AIME in a program of this nature, two organizations stand ready to serve a coordinating and planning function —the WAAIME and the Guidance Committee of the Engineers Council for Professional Development.

The decrease of student enrollment in mineral industry curricula at colleges has prompted the WAAIME to initiate a nationwide program entitled "Engineers for Tomorrow." To cite one example of this program, WAAIME, in conjunction with AIME and the Henry Krumb School of Mines of Columbia University, recently assisted in planning a field trip of high school students to the Grace mine at Morgantown, Pa. A report about this trip appears on the next page.

In addition, to assist our endeavors to stimulate an interest in engineering among the future generations of college students, the Guidance Committee of the Engineers Council for Professional Development is prepared to serve a coordinative role between individual groups, Several years ago, ECPD State Committees were organized to coordinate the efforts of engineering groups engaged in guidance activity, to interest additional individuals or groups in guidance for the purpose of obtaining nation-wide coverage of public, private, and parochial schools, and to promote the adoption of uniform standards for the conduct of this work. These committees work directly with the high schools, counseling students in their course selection, and urging those with the necessary aptitude to consider a career in engineering. Interest in various fields of engineering is aroused through a broad program of films, talks, projects, tours, promotion of high school engineering clubs and science fairs, and individual counseling. There is room for each of us to participate in either or both of the programs offered by WAAIME and ECPD. Should ECPD be able to serve your purpose, contact your State or Regional Chairmen. A listing of these men and their addresses will be found on page 596.

JETS—Junior Engineering Technical Society—is a national organization actively engaged in stimulating an interest in science and engineering among students in our Junior or Senior High Schools. Launched as an experimental project in 1950 by Michigan State University, the program today serves as a cooperative effort through which industry, engineering and scientific societies, and educational institutions may work together to enhance and supplement the science program in the local high school.

Encompassing diverse topics from Fuels and Lubricants to Aeronautics, and including Metallurgy, Crystallography, and Mechanics of Materials, JETS explores science and engineering in a different manner from the usual formal classroom activities. Under the guidance of local engineers, individual or group science and engineering projects are encouraged and may be entered in the annual JETS Engineering Exposition held each May at Michigan State University.

As a sampling, chapter activities may include the following: sponsored trips to industries, construction work, science and industrial exhibits, college campuses; study of technical fields; lectures and talks from engineers and scientists; scientific movies; attendance at engineering and scientific conferences and conventions sponsored by professional societies and colleges.

The interest and activity of JETS in the mineral industry will be proportional to the participation in its program by AIME members. Most mining engineers have not been active in JETS to date although this organization is well-established in secondary schools throughout the country. The present role of JETS in high schools and its potential value to our purpose of interesting young students in the career of a mineral industry engineer warrants our utilizing the services of this organization.

More detailed information about JETS may be obtained by writing to:

JETS, Inc.
Box 589
East Lansing, Michigan

one group did this.....

The decrease in enrollment of mining engineering students was an issue of primary concern at the recent Education Symposium of the Annual Meeting of AIME. The *Journal of Education Yearbook—1959* showed an average of 7.6 engineering graduates from the 29 accredited mining schools in the U. S. It is believed throughout the industry that this diminished enrollment is due in part to the unawareness among high school students of opportunities in the mining industry. In an attempt to dramatize the magnitude of the industry, the challenge it affords, and the financial remuneration available to its members, it was agreed that direct exposure to a mining operation would produce the best results. To aid in combating this decrease in enrollment, the Henry Krumb School of Mines of Columbia University proposed a program to be carried out jointly by the University, the local section of the AIME, and the WAAIME. The initial proposal was to offer a select group of high school students a trip to a nearby mine. This was to be followed up by lectures, distribution of educational literature, and acquainting the students with educational and financial assistance available to them from sources within the indusry.

The cooperation of Bethlehem Cornwall Corp. was solicited to initiate this program. Bethlehem was most cordial in extending an invitation to visit the Grace mine at Morgantown, Pa., and provided proper equipment for the students' use at the mine.

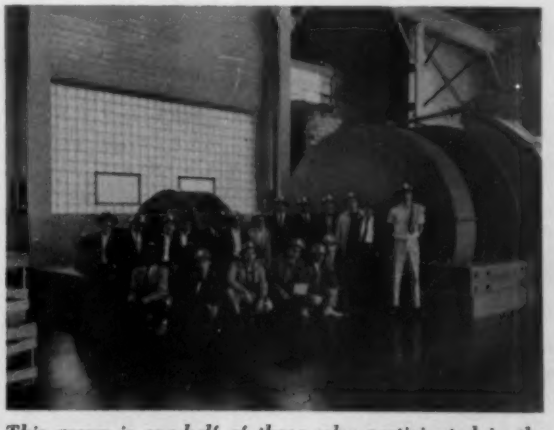
The WAAIME has conducted activities of this nature through their "Engineers for Tomorrow" program. The New York section of this organization was most enthusiastic and helpful in laying the groundwork for planning this program and in rendering invaluable guidance. In turn, the New York section of the Society of Mining Engineers indicated its desire and readiness to provide financial assistance for this trip.

Members of the staff of the Henry Krumb School of Mines, Columbia University, selected a group of students from high schools in the metropolitan New York area. The criteria for selection were high aptitude in basic mathematics and science and a demonstration of interest in the minerals industry. Thirty-four students, representing 12 high schools, were selected for this pilot venture.

On May 6, 1960, this group was taken to the Grace mine at Morgantown, Pa., to inspect surface and underground installations. The trip was supervised by two members of the Henry Krumb School of Mines staff assisted by graduate students from the University. Upon arriving at the property, the students were given an introductory lecture describing general operations at the Grace mine. They were then taken on an inspection tour of the underground mine. The group showed much enthusiasm for this phase of the trip; to quote one student, "The furthest underground I had ever been was in the New York subway system." After examination of the underground workings, lunch was provided by the company. The afternoon session consisted of a visit to the surface plant and milling operations.

Upon completion of the trip, the students were given a questionnaire to ascertain their general reaction to this venture. Although it is impossible to define in quantitative terms the true measure of success, the general comments have been highly favorable. Many have said that prior to this trip they had absolutely no knowledge of the industry and now find it a most challenging and exciting field of endeavor. Some of the students were enough impressed to have voluntarily expressed a definite interest in pursuing mining as a career.

High school students from New York City area view scale models of surface plant and orebody at Morgantown, Pa.



This group is one-half of those who participated in the field trip. Additional trips are planned for next year.

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PLAN AHEAD FOR FALL SECTION MEETINGS

SME Coal Division and AIME St. Louis Section, Joint Meeting

Chase Park Plaza Hotel, St. Louis, September 8-9.

AIME Rocky Mountain Minerals Conference

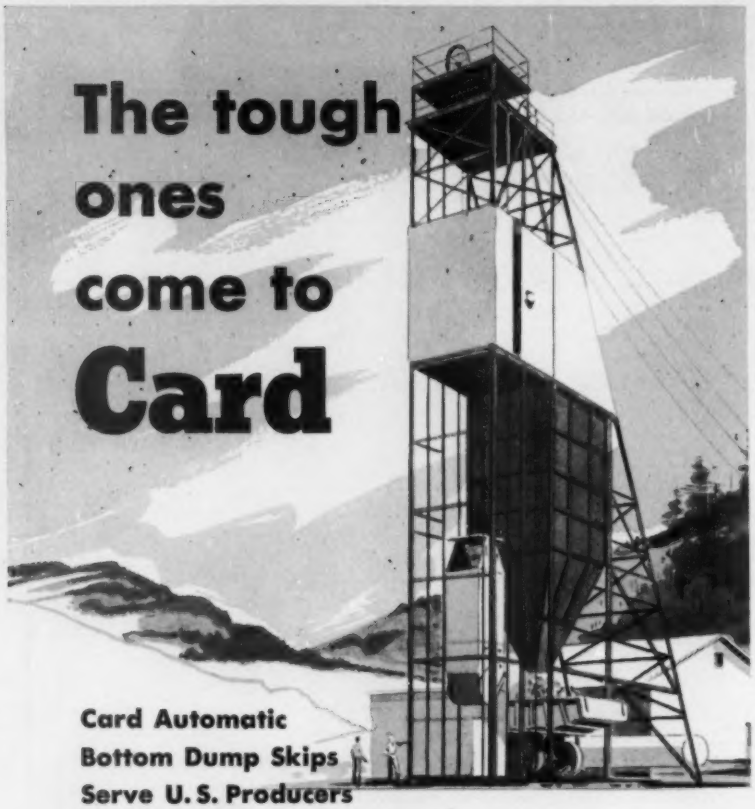
Sixth annual Conference; Utah section host, Newhouse Hotel, Salt Lake City, October 5-7. Program will consist of five technical sessions, followed by field trip. Program details will be published in July issue.

AIME-ASME Joint Solid Fuels Conference

Daniel Boone Hotel, Charleston, W. Va., October 24-25.

Watch for news of nominations, AIME and SME officers. Photographs and biographical sketches will appear in July issue.

The Chase Park Plaza Hotel, headquarters of the SME Coal Division and AIME St. Louis Section meeting, which will be held in St. Louis, September 8-9.



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St. Louis-SME Coal Div. Joint Meeting Program Plans Are Now Detailed

The Joint Conference of the AIME St. Louis Section and the SME Coal Division will be held September 8 and 9 at the Chase Park Plaza Hotel in St. Louis. Registration will begin 8:00 am Thursday, September 8. The following tentative schedule of events has been released:

Thursday, September 8, AM

8:25-8:50

Authors' Breakfast

9:00-12:00

Technical Session

Eugene H. Mauck, *Chairman*

Shaft Sinking and Lining in Illinois Coal Fields: *J. W. McDonald*, Old Ben Coal Corp.

The Winning of Fluorspar—Our Area's Most Strategic Mineral: *Gill Montgomery* and *Durward C. Spees*, Minerva Oil Co.

River King Mine and Mississippi Dock: *W. A. Weimer*, Peabody Coal Co.

Thursday, September 8, PM

12:15

Field Trips

Buses leave Chase Hotel for luncheon at Augustines in Belleville, Ill. Luncheon speaker: *L. S. Jewell.*

2:30

Buses leave restaurant for field trip to River King Mine and Mississippi River Dock.

7:00-7:30

Social Hour

7:30

Stag Dinner and Smoker

Speaker to be announced

Friday, September 9, AM

9:00

Technical Session

Dave Davis, *Chairman*

The Adaptability of Illinois Coals for use in Iron and Steel Production: *Hubert E. Risser*, Illinois Geological Survey.

Oklahoma-Arkansas Coals: *B. L. Curry*, Lone Star Steel Co.

Meramec Mining Company's Pea Ridge Project, *E. L. Bilheimer*, Meramec Mining Co.

Stream Pollution: *Clarence W. Klassen*, Chief Sanitary Engineer, Illinois Dept. of Public Health and member of ORSANCO.

The Conference will adjourn at 12:30 pm on Friday.

Mexico Section Honors AIME, SME Presidents

President's night for the Mexico City Section, March 7, turned into a double presidential affair when, in addition to Joseph L. Gillson, President of AIME, A. B. Cummins, President of SME turned up unexpectedly and attended the meeting.

Festivities began Sunday, March 6, when Enrique Madero, chairman of the Section, and his charming wife Beatris entertained the executive committee, and committee chairmen and their wives at their beautiful home in Cuernavaca. Here spring welcomed the northern visitors with Jacaranda trees in full blossom. Following dinner, Jack Carty, the Section secretary, entertained with his version of pachydermic diving in the swimming pool.

The main affair was ladies' night at the University Club which brought out a record attendance. The group included such prominent members of the mining fraternity in Mexico City as Oswaldo Gurria Urgell, director of Comisión de Fomento Minero, and his señora; Sr. and Sra. Salvador F. Treviño and Sr. and Sra. Salvador S. Peño, respectively, general manager of Fomento Minero, and Under Secretary of Mines for Mexico; Mr. and Mrs. John G. Oliver, Mineral Attaché at the U.S. Embassy; Ken Hardy, Mr. and Mrs. Joe Yaeger, and Mr. and Mrs. Chuck Campbell, all of American Smelting & Refining Co.; Harold and Isabel Jaquet of Pan American Sulphur Co.; José Garcia and his vivacious wife Chunga who is vice chairman of WAAIME; George and Less Ordoñez of Kennecott and their son Zeke; Sr. and Sra. Guillermo Salas; Mr. and Mrs. Arthur Geyne; Mr. and Mrs. Jack Despins of Allis-Chalmers; Sr. and Sra. Ramon Eberstadt of Joy Mfg. Co.; Sr. and Sra. Manuel Villafaña of Asarco; Sr. and Sra. Alfredo Terraza, who put on the AIME meeting in 1951 that is so well remembered; Mrs. Frank Loretta, and Mr. and Mrs. William Schiele of Du Pont.

President Gillson gave a short talk in which he congratulated the Mexico Section and the WAAIME's for the wonderful work they are doing in providing scholarships for Mexican students at Mexican universities. The Section has the highest local dues in AIME and levys an extra assessment if necessary to carry out this work.

Head table guests at the Mexico City Section on March 7 include, left to right: Maria Teresa de Franco Lopez; Oscar Chávez, vice chairman of the Section; Mrs. Gillson; Enrique Madero, Section Chairman; Alicia Chávez, WAAIME president; Joseph L. Gillson, AIME President; Beatris Madero; Manuel Franco Lopez, president of the Mexican Soc. of Mining Engineers, Metallurgists, & Geologists; A. B. Cummins, SME.

Sky view of St. Louis municipal airport.

AIME's International Agglomeration Meeting Plans Proceed for 1961

AIME will sponsor an International Symposium on Agglomeration in Philadelphia, Apr. 12, 13, and 14, 1961. The Symposium will deal with the processes of sintering, pelletizing, nodulizing, briquetting, powder metallurgy, ceramic bonding, and related processes. Areas of application will include ferrous and nonferrous ores as well as carbonaceous materials, ceramics, and other nonmetallics. Emphasis will be principally on the fundamental aspects of agglomeration. The preliminary program follows:

Wednesday, April 12

AM **Characterization of Raw Materials**

Noon **Welcoming luncheon**

Speaker: *R. R. McNaughton*, AIME President (1961)

PM **Preparation of Raw Materials**

Thursday, April 13

AM **The Agglomeration Process-I**

PM **The Agglomeration Process-II**
Fellowship Dinner

Friday, April 14

AM **Evaluation & Utilization of Products**

PM **Economics & Process Design**

A special ladies' program will be arranged during the Symposium.

All phases of the subject will be covered by technical papers being written by specialists from all over the world. The papers will be presented in abstract form and then discussed. All papers accepted for the Symposium will be preprinted and mailed to pre-registrants well in advance in order that appropriate discussions can be prepared. The preprints will include abstracts in English, French, and German.

Proceedings of the Symposium, the technical papers together with the discussions, will be published in a bound volume and will be mailed to all registrants promptly after the Symposium.

Registration fee for AIME members is $25 and for nonmembers, $27.50. The fee includes one set of preprints and one volume of *Proceedings*. Students registration is $5 (does not include preprints or *Proceedings*).

For further information write:
W. B. Stephenson, General Chairman, AIME International Symposium on Agglomeration, P.O. Box 635, Paoli, Pa.

AMC 1960 Mine Show

The American Mining Congress 1960 Mining Show will be held in Las Vegas, Nev., October 10th through 13th. There is still time to take active part in this every-other-year gathering of the metal mining-industrial minerals industry by becoming an exhibitor or a sponsor. For further information write Julian D. Conover, Convention-Exposition Director, American Mining Congress, Ring Bldg., Washington 6, D.C.

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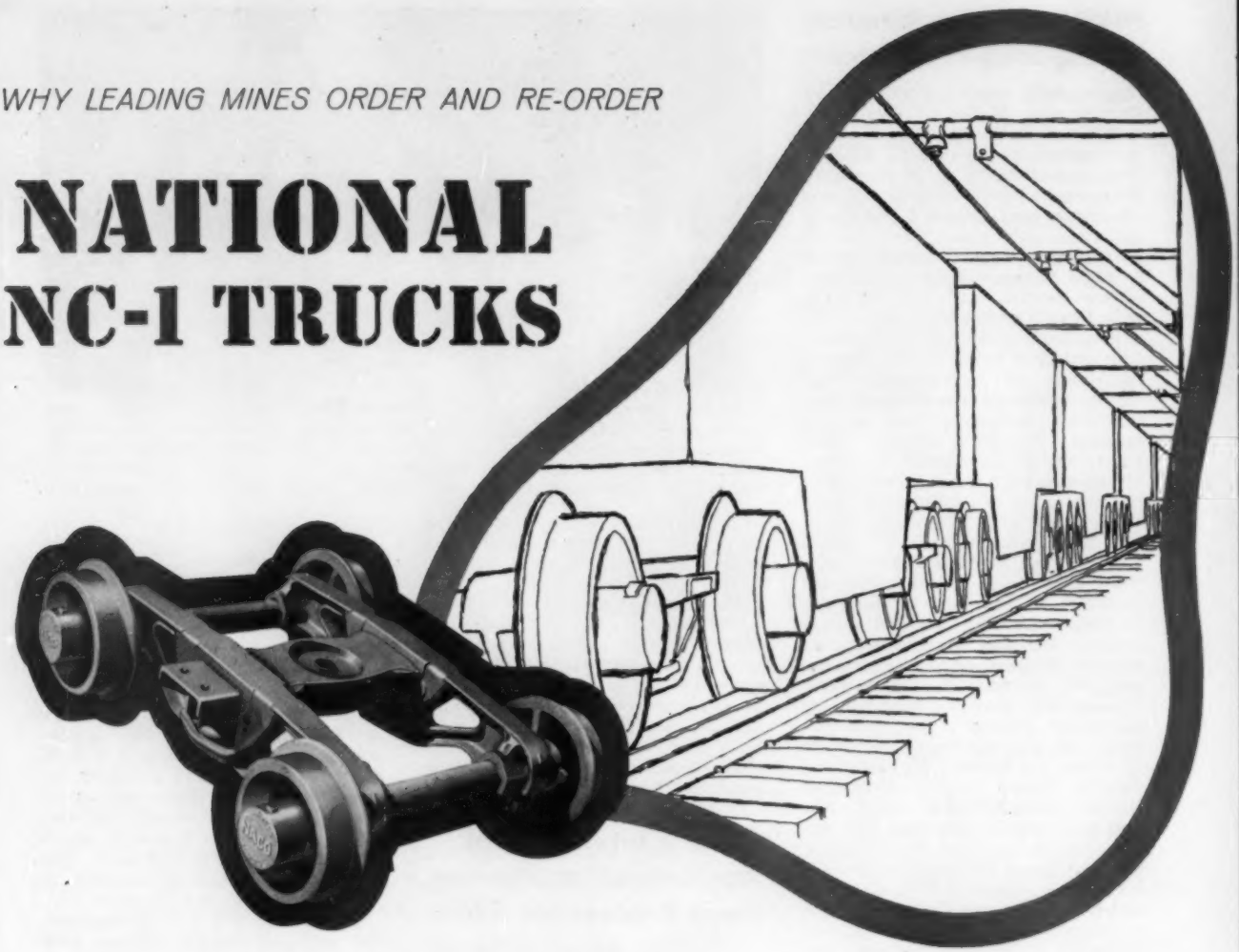

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Mining & Exploration Division

Few M&E members are able to attend all of the professional and technical meetings held throughout the year that would be of interest to them. To help keep M&E'ers up to date on these, the following letters are presented.

Dear Mr. Chandler:

The Prospectors and Developers Assn. held its 28th annual convention in Toronto from March 6 to 9. People directly connected with or interested in the finding and developing of mines find this convention invariably stimulating and very worthwhile. There were a number of excellent papers on new areas in Canada, and also on new mining camps in the making, such as the Thompson-Mvak Lake nickel belt in Manitoba and the Mattagime base metals camp in Quebec. General topics included a financial symposium in which mine financing problems were discussed and an exploration symposium in which the current slowdown in mineral search was studied. The future for base metals was analyzed in an excellent talk by Simon D. Strauss.

Yours very truly,
Roy Jure
American Metal
Climax Inc.

Dear Mr. Chandler:

The 62nd annual general meeting of the Canadian Institute of Mining and Metallurgy was held in Toronto from April 25 through 27. Meeting jointly with the CIM were the Geological Assn. of Canada and the Mineralogical Assn. of Canada.

The program included a symposium on *Mineral Energy Sources - Present and Future*. In discussing uranium, it was pointed out that while there is little doubt that the low cost Canadian uranium producers will be competitive in the world markets, the industry will have to pay close attention to operating costs. It was stated that to be competitive, a mine must be capable of showing a profit with a price of $5 per lb U_3O_8 and to be able to exist on prices of from $4 to $4.50 per lb.

Among the many interesting papers given by the Metal Mining Div. was an outstanding presentation of mining operations at Consolidated Denison Mines. This paper was published in the March 1960 issue of the *CIM Bulletin*. This unique mining operation which employs trackless haulage with conveyor belts was described in considerable detail. A number of efficiency tables (work standards) are given which would be of invaluable help to anyone engaged in this type of mining.

There were some interesting papers given on mineralogical studies. Two of these, concerned with the study of pure minerals and given under the auspices of the Mineralogical Assn. of Canada, were of timely interest as they dealt with niobium minerals or niobium-bearing minerals. This pointed up the sometimes unrecognized connection between the pure sciences and economic technology.

Dr. George Aletan's paper on the relation between microscopic studies and beneficiation work on Brunswick ore was very pertinent. His photomicrographs in color were excellent.

The paper on *Uranium Oxide Recovery at Consolidated Dension* by the mill staff was an excellent record of this operation. Two pertinent comments were made. One concerned the controversy over pachuca vs mechanical agitators. Experience has now shown that, at the coarse grinds used in Blind River area, the large mechanical agitators are not entirely satisfactory and pachucas are preferred, although it is not always economical to make a change in existing plants. For precipitation of U_3O_8 the choice is between magnesium oxide and ammonia. The former is preferred for its ease of handling, but recent changes in AEC specifications for calcium content have compelled them to change to ammonia. This requires more expensive equipment and careful operation.

The symposium on *Materials Handling in Acid Slurries* was timely and brought out a lot of information based on experience in many different operations during recent years. This should be of considerable value in future plant design.

Yours very truly,
Richard H. Ross,
Roy Jure
American Metal Climax Inc.

Annual Meeting Plans

February 1961 may still seem a long way off but planning is already underway for the Division's share in the program. J. M. Ehrhorn, vice president responsible for programs, has issued a general statement regarding the policy governing the programming:

"The big change in programming has to do with the number of sessions. The Mining and Exploration Division plans seven sessions for the St. Louis meeting. There will be one session devoted to each of the subdivisions of open-pit mining, underground mining, geology, geophysics, and geochemistry. One session, that of Wednesday afternoon, will be devoted to the Jackling lecture. There may or may not be an additional item such as was covered during the meeting of last February. The seventh session will be a research symposium of three parts devoted to applied research in mining, applied research in exploration, and fundamental research in the earth sciences and mining engineering.

"Reduction of the number of sessions will conform with the overall objectives of SME and should be a move towards the elimination of overlapping sessions. The unit program chairman will be called upon to select the papers with utmost care in order that the programs will attract the greatest number."

Geochemistry

Douglas R. Cook, geochemical program chairman, issued the following statement:

"In view of the large amount of geochemical data being accumulated by various organizations, and often the difficulty in their interpretation, it is pro-

(Continued on page 602)

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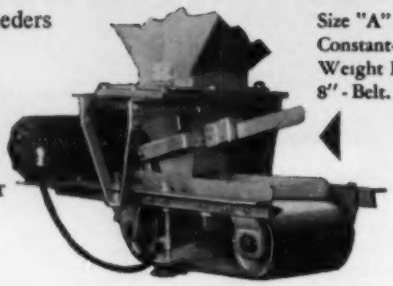

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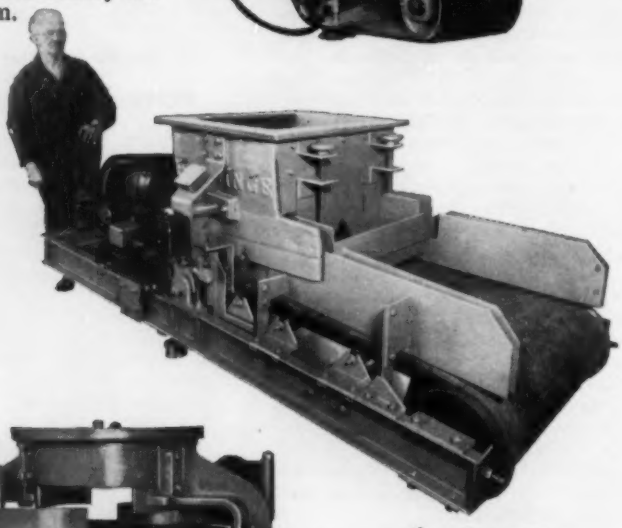

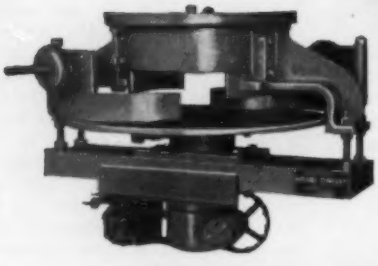

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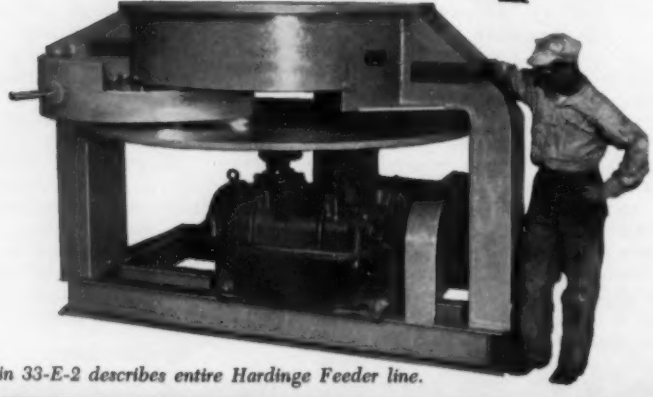

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(Continued from page 601)

posed that part or all of the 1961 geochemistry program be devoted to statistical and mathematical methods in analysing these data. It may also be desirable to include in this program a paper or two dealing with probability and statistics as applied to mineral exploration in general. Anyone who is able to contribute to this subject and who is willing to present a paper at the 1961 annual meeting should write to:

Douglas R. Cook,
Geochemical Program Chairman
Coordinating Unit,
Bear Creek Mining Co.,
2121 South State St.,
Salt Lake City, Utah.

Geophysics

Don A. Hansen, geophysics program chairman, states that the tentative theme for the geophysics session is *Geophysics as a Tool for the Geologist and the Engineer*. The reasons for selecting this theme, he explains, are:

> "Many mineralized zones of potential economic value are not directly detectable because of great depth of burial or lack of sufficient physical property contrast with the unmineralized rock. In such cases the techniques of geophysics may greatly aid the understanding of the geologic picture by defining the distribution of geologic structures and lithologic units. Also, most geophysical surveys do not result in the detection of mineralization, but many of these negative surveys do produce structural or lithologic information of value to the geologist. I believe this aspect of geophysics deserves some emphasis."

As to specific information concerning the session, Mr. Hansen writes:

> "During the 1961 meetings there will be no concurrent sessions within the Division. We, therefore, expect the audience at each session to be representative of the Division membership. For this reason I feel that papers should be of the case history type in that they present an exposition of results and of geologic interpretations obtained by various geophysical techniques. A paper, however, need not be a case history in the sense that only a single geographic area or geologic problem is treated.
>
> "The geophysics papers will be presented at a single morning

(Continued on page 608)

Fall Meetings Around the Country to Keep Division Members on the Go

Joint Meeting Set For St. Louis in September

Coal Division News readers are reminded to mark their calendars and make reservations to attend the Joint Meeting of the St. Louis Section of AIME and the Coal Division of SME in St. Louis September 8 and 9. Conference headquarters is the Chase Park Plaza Hotel.

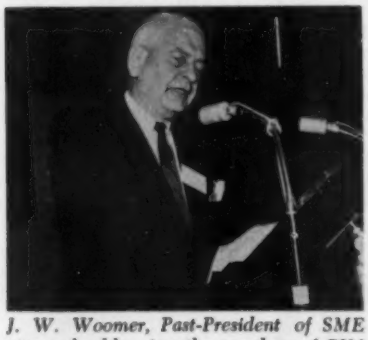
Registration begins Thursday morning at 8:00. The tentative program for the conference will be found elsewhere in this issue of MINING ENGINEERING. A glance at it will show the value of the technical sessions to anyone primarily interested in the mining and uses of coal.

ASME-AIME Joint Solid Fuels Meeting Planned

The 23rd Annual AIME-ASME Joint Solid Fuels Conference will be held October 24 and 25 at the Daniel Boone Hotel, Charleston, W. Va. The theme of this national conference will be *Economics in the Production and Utilization of Coal.* Here is a chance to participate in the consideration of a vital and timely topic affecting the people of coal-producing states.

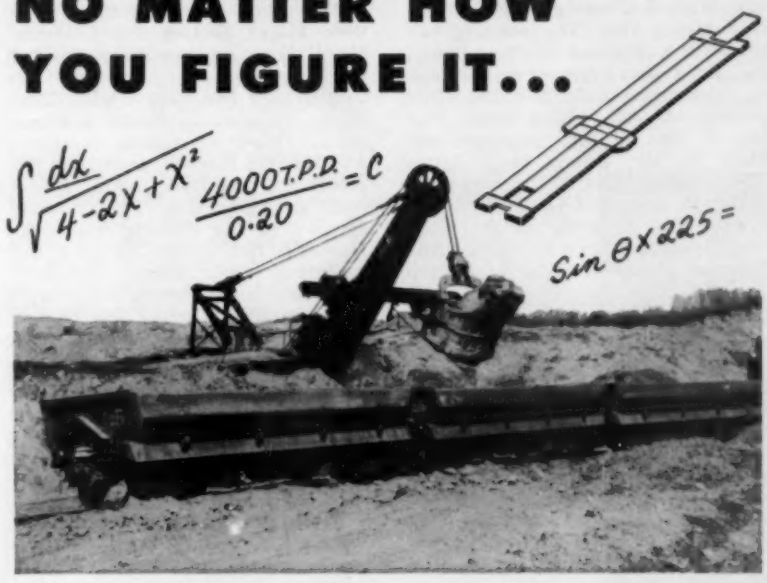
Greenbrier Hotel to be Site of Fall Conference

The West Virginia Coal Mining Institute and the Central Appalachian Section AIME have scheduled a joint meeting to be held November 4 and 5 at the Greenbrier Hotel, White Sulpher Springs, W. Va. John L. Schroder, Jr. and Fred Toothman are co-chairmen of the program committee. They are working on an agenda which they hope will prove to be timely, interesting, and helpful to the membership.



J. W. Woomer, Past-President of SME pictured addressing the members of CIM at their annual meeting in Toronto.

NO MATTER HOW YOU FIGURE IT...



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Around the Sections

• The **Colorado Section** held their monthly dinner meeting April 21 at the Petroleum Club in Denver. Edward L. Clark, Director of National Resources, State of Colorado, was guest speaker. His subject was *Need for Coordinaton within the Mineral Industries.*

• The **Utah Section** inaugurated a new type of meeting with the one held March 16th. The evening began with cocktails at the Fort Douglas Club House followed by a dinner in the Panorama Room of the University of Utah Union Bldg. The formal part of the meeting took place in the Union Bldg. Little Theater with Dr. C. J. Lewis, of the Colorado School of Mines Research Foundation, as guest speaker. Dr. Lewis' subject was *Chemical Approaches to the Winning of Metals.*

• The annual joint meeting of the **Montana Section** and the Montana Soc. of Engineers was held at the Montana Hotel in Anaconda, March 26. A social hour and dinner were followed by the speaker of the evening, Edward Bonner of The Anaconda Co., who presented an illustrated paper by E. I. Renouard, vice president in charge of western operations of The Anaconda Co., entitled *The Butte Mining District.* As an adjunct to this meeting, the Woman's Auxiliary held a dinner meeting at the same time.

• Dr. Joseph L. Gillson, AIME President, was guest and speaker at the **Tri-State Section** March 23rd meeting held at the Mickey Mantle Holiday Inn, Joplin, Mo. Dr. Gillson showed colored slides on *Pre-Columbian Ruins in Mexico.* Another feature of the meeting was the presentation of a $75 award to Miss Molly Havens, a senior in Joplin high school, for her winning essay, *Crystalline Form,* in the Section's essay contest on the mineral industry.

MOLLY HAVENS & C. O. DALE

J. L. GILLSON

• The **Morenci Subsection** of the Arizona Section met at the Longfellow Inn April 12th where a color film on the *Interstate Highway System* was shown. Oscar T. Lyon, Jr., District 3 Engineer of the Arizona Highway Dept., was in charge of the presentation and gave a talk on the major points and development of the program in Arizona. A question and answer session followed.

• The April 14th meeting of **The Ohio Valley Section** was Students' Night. Four undergraduates of the Earth Sciences at Ohio State University gave five minute talks. They were: William C. Beard, geology; Adrain Mathias, mining engineering; Howard Henney, petroleum engineering; and Russ Orkin, metallurgical engineering. The principal speaker of the evening was Dean Harold A. Bolz of the College of Engineering, Ohio State University who spoke on *Designing Tomorrow's Engineer.* The meeting was held at the Riverside Restaurant in Columbus.

• The **Maricopa Subsection,** Arizona Section, met February 4 at the Westward Ho Hotel in Phoenix where they heard Charles A. Anderson, USGS, give a talk on *Geologic Conditions in Arizona.*

At the March 3rd meeting, in the same place, P. D. I. Honeyman, recently retired as president of Inspiration Consolidated Copper Co., was guest speaker. His subject was *History and Future of Inspiration, the International Smelter and the Christmas Mine.*

• Members of the **St. Louis Section** had a busy weekend April 7th and 8th. Thursday evening, April 7th there was a joint meeting with the Engineers Club of St. Louis at 4359 Lindell Blvd. Earl L. Bilheimer, resident manager of the Meramec Mining Co., spoke on *Pea Ridge Iron Ore Body* illustrating his talk with slides covering the area, equipment, and construction of the project from its inception to the present. Friday, April 8th, the Section took a tour of mining and metallurgical departments, University of Illinois and Illinois Geological Survey. Tours through the laboratories and facilities of these organizations began at 2:00 pm. In the evening there was a dinner at the Tilden Hall Hotel, Champaign, Ill. The speaker of the evening was Demitri Shimkin who addressed the group on *Development of Mineral Fuels in the Soviet Union.*

H. A. Franke, membership chairman, accepts membership award of a gavel from Howard C. Pyle on behalf of the Pittsburgh Section.

• The **Pittsburgh Section** met March 15th at the Gateway Plaza Restaurant where E. J. Ostrowski spoke on *Use of Natural Gas in the Experimental Blast Furnace.*

The April 12th meeting featured a color film *Stars that Shine Forever* on the development of a diamond from its rough condition in the mine through the cutting processes that turn it into a finished gem stone. The ladies were invited to this program.

This was also the Section's annual business meeting. The following officers were elected: Robert E. Lund, chairman; Allen S. Russell, first vice chairman; Robert G. Redelfs, second vice chairman; W. M. Mahan, secretary-treasurer; and F. L. Convers, A. R. Ellenberger, and J. K. Gregg, executive committee.

The Pittsburgh Section announced with pride that its 1959 membership goals won them an award for submitting the largest number of applications relative to any other AIME Section in the group having over 600 members. It also lead to its becoming the second largest Section of AIME in the world, surpassing New York for the first time. Their 1960 efforts will be directed toward surpassing the Gulf Coast Section to become the top Section in membership.

• The **San Francisco Section** met April 13th at the Engineer's Club where A. F. Dailey, placer mining consultant, spoke on *Outline of African Diamond Industry* which he illustrated with colored slides.

Personals

After eight years in Marietta, Ohio where he was superintendent major alloys for Union Carbide Metals, **Fred L. Evans** has been transferred to their plant in Niagara Falls, N. Y. as assistant plant manager.

William J. O'Connor, president and general manager of Independence Coal & Coke Co., Salt Lake City, was recently chosen Utah's Man of the Year in Education. He joined the Board of Regents of the University of Utah in 1949 and was its chairman from 1951 to 1959.

Eugene R. Glazier, Denver, and **Harvey L. Stahl,** Dallas have recently been named sales representatives to district offices of Allis-Chalmers Industries Group upon completion of the company's training course for graduate engineers.

C. Williams Davis was elected president of the Southern Coal Producers Association at a special meeting of the board of directors March 18 to succeed **Joseph E. Moody.** Mr. Davis has been executive secretary of the Bituminous Coal Operators Association, Washington, D. C. since July 1958.

F. E. Estes retired March 1 as head of the National Coal Association Transportation Dept. after 41 years with the Association.

Jack D. Powers has been named central district manager for Hardinge Co., Inc. with headquarters in Chicago. Since 1952 he has been manager of engineering in the Research Div. of the Chicago Stock Yards.

At the annual meeting of the Nevada Mining Association Inc. held in Reno Jan. 15, 1960 the following members were elected to serve as directors for the ensuing term: **Henry S. Curtis,** American Potash & Chemical Corp.; **Roy A. Hardy,** Getchell Mine Inc.; **Robert O. Jones,** Standard Slag Co.; **William L. Kendrick,** Manganese Inc.; **John C. Kinnear, Jr.** Kennecott Copper Corp.; **John C. MacDonald,** Flintkote Co.; **A. E. Millar,** The Anaconda Co.; **H. P. Willard,** Basic Incor.; and **S. H. Willinston,** Cordero Mining Co.

The Board of Directors held a special meeting in Las Vegas, Jan. 28, 1960 to elect officers: **J. C. Kinnear,** honorary president; **John C. Kinnear, Jr.,** president; **Robert O. Jones,** first vice president; **Roy A. Hardy,** second vice president; and **Louis D. Gordon,** executive secretary.

Joe Hales, former New Mexico deputy mine inspector, has been appointed safety and industrial hygiene technician for the Chino Mines Div. of Kennecott Copper Corp. Mr. Hales has served as deputy mine inspector for southern New Mexico since 1955. He will be succeeded in this position by **David P. Aker** of Santa Rita. Mr. Aker has had 12 years experience in hard rock mining and shaft sinking.

C. Kenneth Tudor is now associated with International Minerals & Chemical Corp. in the new position of mine superintendent, responsible for all production from the entire mining operation. Mr. Tudor comes to Carlsbad from Jewell Ridge Coal Corp., Tazewell, Va. where he had been mine superintendent for the past three years.

Gary R. Radcliffe has taken a position with the LeRoi Div. of Westinghouse Air Brake Co. as drilling specialist in the sales department.

Engineering Societies Personnel Service Inc. recently announced that **Richard M. Stewart,** supervising geologist, California Div. of Mines, has been elected secretary of the Service's San Francisco Advisory Committee. He succeeds **Eric Salo** who is now vice chairman.

Lewis A. Phillips has been appointed chief industrial engineer for the Carlsbad, N. M. potash operations of United States Borax & Chemical Corp. according to a recent announcement of the resident manager. Mr. Phillips was formerly associated with the Ethyl Corp. of Baton Rouge, La., serving as time and methods engineer and as engineering economist.

Douglas J. Kramm has been appointed lime and chemical kiln sales engineer by the Traylor Engineering & Mfg. Co. Div. of the Fuller Co. it was announced recently. Mr. Kramm will be located in Traylor's main offices in Allentown, Pa. Prior to this, Mr. Kramm has been district sales manager for Traylor's San Francisco office.

L. A. PHILLIPS

D. J. KRAMM

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Spokane, Washington . . . . WAlnut 4-2614
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personals

continued

G. C. Armstrong, formerly director of instrumentation at South Plains College, Levelland, Texas, has become a sales engineer for The Bristol Co., serving the Missouri-Illinois area from their district office in St. Louis.

H. C. Bauman, American Manganese Steel Div., American Brake Shoe Co., has been transferred to Denver as district sales manager. He had been working out of Salt Lake City as a sales representative for the company.

F. J. Budin, Burma Corp. Ltd., has been spending a six-month leave visiting mines in Germany. He returns to Rangoon early in June.

S. A. Hanson who had been chief engineer for Liberia Mining Co. Ltd. has become general manager for Mine Management Assoc. Ltd. in Monrovia, Liberia.

P. T. Menoher, Owens-Illinois Glass Co., has been transferred from San Francisco where he was manager of its quality research laboratory to its Portland, Ore., plant as finished products supervisor.

Cyrille Dufresne, Iron Ore Co. of Canada has been transferred from the Knob Lake operations at Schefferville, Que., where he was an exploration engineer to the company's new Coral project at Wabush Lake, Nfld., as chief engineer. The project involves the development of large deposits of low grade iron ore and construction of a seven-million-ton concentrator to be completed by the fall of 1962.

Paul J. Mills, former general mine foreman with The New Jersey Zinc Co., has joined American Zinc, Lead & Smelting Co., Vinegar Hill Div., Shullsburg, Wis., as mine superintendent.

James Boyd, former vice president-exploration, of Kennecott Copper Corp., has been elected president and chief executive of the Copper Range Co. He took up his new position in May at the company's headquarters in Boston.

Upon completion of his studies at Michigan College of Mining and Technology, **Ken Taylor** has taken a position as junior geologist with Lamaque Mining Co. Ltd., Bourlamaque, Que.

Allis-Chalmers Mfg. Co. recently announced the appointment of **Robert L. Halsted** as manager of the Milwaukee district to succeed **A. P. Bowman** who has been transferred to North Central regional headquarters in Chicago as manager of Industrial Equipment Div. sales. Mr. Halsted has been with Allis-Chalmers since 1935 when he became a sales representative in the Cincinnati district office. Mr. Bowman started in with the company in 1948 as a sales representative in the Chicago warehouse sales unit.

Charles E. Johnston has joined International Minerals & Chemical

Stephen F. Dunn, *left, president National Coal Assn. and* **F. Stillman Elfred,** *right, chairman of the board, show President Eisenhower a model of the world's largest coal stripping shovel. U.S. government, coal's No. 1 customer, buys 30 million tons a year.*

Corp. in Carlsbad, N.M., as mine engineer. Prior to accepting this position, Mr. Johnston had been mine superintendent for the Grand Rapids Gypsum Co.

F. J. WEISHAUPL

P. WEIR

Franklin J. Weishaupl was recently cited by Lt. Gen. George W. Mundy, USAF, Commandant of the Industrial College of the Armed Forces, Washington, D. C., for having successfully completed the college's correspondence course. The course entitled *The Economics of National Security* is based on a ten-month resident course devoted to the study of the geoeconomic factors of national and international affairs.

Paul Weir, chairman of the board of the Paul Weir Co. Inc., Chicago, returned recently from an unique technical mission to Coalbrook, Orange Free State, South Africa, the scene of the Jan. 21, 1960, disaster which claimed the lives of 436 miners. Mr. Weir was engaged by the owners, the Clydesdale Collieries Ltd., to join Sir Andrew Bryan, British coal mining authority, to investigate probable causes and to make recommendations. Mr. Weir is the only living American honorary member of the United Kingdom's Inst. of Mining Engineers.

Kennecott Copper Corp. recently announced the election of **C. Harry Burgess** as vice president, exploration. Mr. Burgess has been president of Bear Creek Mining Co., Kennecott's domestic exploration subsidiary, for the past four years. He joined the Kennecott organization in 1952 as a geologist.

Adolph V. Mitterer has been promoted to the Mining and Exploration Dept. of the Research Div. of International Minerals & Chemical Corp. with headquarters in Skokie, Ill. However, Mr. Mitterer will continue working in Carlsbad, N.M., for several months at least, working on Carlsbad production problems. Before his promotion he was serving as chief mine engineer.

Leonard J. Keller has joined Monsanto Chemical Co. as production engineer. He had formerly been with Virginia-Carolina Chemical Corp. as general superintendent of their Tennessee Mining Dept.

Frank. W. Millsaps who had been a test engineer with Phelps Dodge Corp., Copper Queen Branch, has joined Tungsten Mining Corp., Henderson, N.C., as mill superintendent.

Arthur H. Yarberry has left Silica Corp. of America for the job of superintendent with National Quarries Ltd. in Montreal.

The M. W. Kellogg Co., New York, recently announced the appointment of **John A. Swart,** mining engineer, as project manager in its Ore Dressing and Beneficiation Group. Before his recent appointment, Mr. Swart was chief engineer for Foley Brothers, New York, on construction of the Chuquicamata sulfide plant, Chile.

Gailen T. Vandel, Marcona Mining Co., has left San Francisco to work at the company's operations in Lima, Peru.

Mark Lintz, mining and metallurgical engineer is currently located in Mexico on phosphate exploration work in Coahuela, Zacateca, and San Luis Potosi.

Jose A. Arguedas who had been with Cerro de Pasco Corp., La Oroya, Peru, has joined Western Knapp Engineering Co. as a project engineer in Los Altos, Calif.

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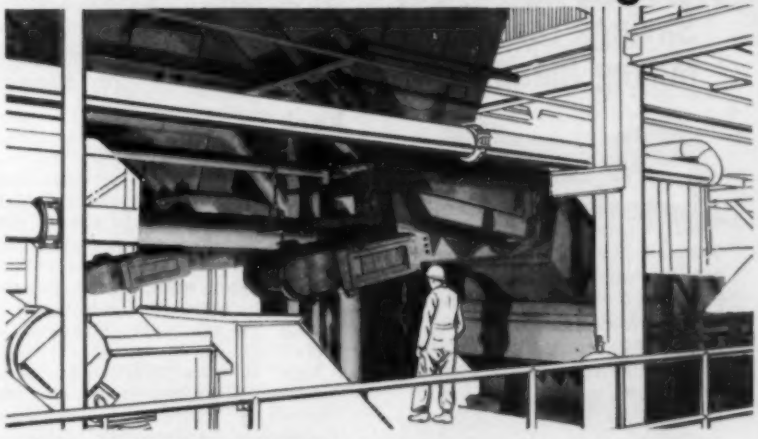

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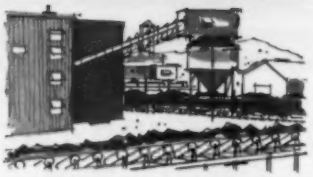

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personals

continued

The Anaconda Co. recently announced the appointment of **Edward O. Bonner** as general superintendent of the Butte mines to succeed **Andrew R. Sims** who has retired after 44 years with the company. Mr. Bonner has been with Anaconda since 1936. Before his present appointment, he was assistant general superintendent of mines, the position he has held since 1952.

W. P. Horne has recently retired from the Mines and Geological Dept., Kenya Colony, East Africa, and will make his home in London, England.

G. W. Thomas has gone to Northern Rhodesia to work for Mufulira Copper Mines Ltd. He had formerly been with Benguet Consolidated Inc. in the Philippines.

F. R. Thornton has left American Cyanamid Co. In Brewster, Fla., to move to Chile where he will work for Braden Copper Co.

Wayne E. Stiefvater, of Denver; **Robert O. Schuelke, Jr.**, of Lakewood; and **Douglas F. Farris**, of Golden were awarded full four-year scholarships to the Colorado School of Mines as winners in the statewide Engineers' Day examination. The awards were made during the opening session of the School's 26th annual E-Day, a yearly careers' exposition devoted to illustrating the mineral engineering professions. Three hundred fifty students in 60 Colorado high schools took the examinations. The winners were the top three finalists.

Eric A. Peterson has moved to Cherry Point, N. C., from Altadena, Calif., to take a job with the Public Works Office of MCAS.

Rock in the Box

(Continued from page 602)

session. In order to allow time for discussion after each presentation, the number of papers will be limited to three or four, of 20 to 30 min each. Possible papers could come under three general classifications: 1) *Geologic Mapping by Airborne Geophysical Methods*, an exposition of lithologic or structural information derived from one or more of the airborne geophysical methods; magnetic, radiometric, electromagnetic including AFMAG, etc.; 2) *Geologic Mapping by Ground Geophysical Techniques*, an exposition of the structural or lithologic information derived from the application of ground geophysical techniques; magnetic, gravity, resistivity, induced polarization, etc.; and 3) *Engineering Applications of Geophysics*, a demonstration of the application of geophysical methods to foundation problems, water supply, depth of overburden, rippability of overburden, etc."

Comments and suggestions on the proposed program should be sent to:

Don A. Hansen,
Geophysics Program Chairman
Plaza Terrace Bldg.
445 East 2nd South
Salt Lake City, Utah

EDITOR

John W. Chandler

American Metal Climax Inc.
1270 Ave. of the Americas
New York 19, New York

Barrett Gives Plea For New Building Funds; Cites Hoover Ceremony

This historic event took place shortly after Mr. Hoover's 85th birthday. He had given freely of his time and money in assisting in the furtherance of this project because of his sincere interest in the welfare of the profession and of the societies and because of his appreciation of their importance to the nation.

The building fund goal of $12,560,000 is still $1,500,000 short of attainment. To quote W. J. Barrett, past-president of UET, "If you have not yet made a contribution or pledge won't you do so now? If you can add to a previous contribution, please do so. The building will be ready for occupancy by mid-1961. Won't you help to have it paid for by that time?"

W. J. Barrett, past-president of UET and AIEE, took the photograph of the ground-breaking ceremony.

Herbert Hoover breaking ground for the United States Engineering Center.

Obituaries

Evan Gerrit Lewis

An Appreciation in Behalf Of
The AIME *Ajo Subsection* By
Alfred T. Barr

Evan Gerrit Lewis (Member 1949), retired concentrator superintendent for Phelps Dodge Corp., died on June 18, 1959, at his home in Ajo, Ariz., at the age of 70. He had spent nearly a half century in his profession as a metallurgist and contributed greatly to the progress in the science of ore dressing which was achieved during his lifetime. He also gave generously of his time and talents toward the betterment of community life in the mining towns where he was employed, and his passing was mourned not only by his many professional associates but also by all who had come to know his kindly nature.

Evan Gerrit Lewis was born in Orange City, Iowa, on July 18, 1889. The family moved to Moscow, Idaho, when Evan was 14 years old and there he obtained his high school and college education. He graduated from the University of Idaho in 1910 with a B.S. in mining engineering.

Mr. Lewis was employed for five years following graduation by the Yukon Mining & Smelting Co. in White Horse, Yukon Territory, leaving there in 1915 to join The Anaconda Co. at Anaconda, Mont.

Mr. Lewis joined the Phelps Dodge Corp. in January 1926 and was continuously employed by them for over 28 years. He came to Ajo as metallurgist for the New Cornelia Branch in May 1934, and served in that capacity until July 1942 when he was appointed concentrator superintendent. He served as concentrator superintendent until his retirement on Aug. 1, 1954, and as a consultant in ore dressing for some time after his retirement.

Mr. Lewis became a member of AIME in 1949, and in 1952 served as chairman of the Ore Dressing Div. of the Arizona Section. He also gave freely of his time to the affairs of the AIME Ajo Subsection whenever called upon for help.

Chester Harkins Steele

An Appreciation By
A Committee of the
Montana Section

The members of the Montana Section of AIME are deeply grieved by the death of Chester Harkins Steele (Member 1916) on the morning of May 19, 1959, at the Community Memorial Hospital, Butte, Mont. His associates and friends were greatly shocked to learn of his sudden passing.

Chester, as best known to many, was born in Portland, Ore., on April 5, 1894, from where he came to Butte with his parents and a brother in 1910. He was graduated from the Butte High School in 1912 and in 1916, he received the degree of engineer of mines from the Montana School of Mines. In 1940 he was honored by his alma mater with the professional degree of geological engineer. He became associated with the Geology Dept. of The Anaconda Copper Mining Co. immediately after his graduation in 1916. In 1948 he was promoted to head of the Geology Dept. of the Butte Area. In the following years, he not only continued to prove his ability in the field of geology, but also showed great interest in the development of mines and mining operations in Butte with the result that he was appointed general manager, Western Mining Operations of The Anaconda Copper Mining Co. in 1952. A few months later, he was again advanced to vice president in charge of Western Mining Operations, the position he held at the time of his death. He was also an officer or director of many subsidiary organizations of The Anaconda Co., a director of the Montana Power Co., and the Metals Bank & Trust Co. of Butte.

His professional reputation was outstanding. His precise work in examining and mapping geologic structures in the mines of Butte, as well as many North American prospects and mines, combined with his most careful interpretations of the problems involved, served him well during periods of mining litigations. His forthright statement of facts and findings, as he observed and interpreted them, won him the sincere respect of the legal profession and jurists during protracted hearings of witnesses and legal counsel for both defendents and plaintiffs in court proceedings.

He took a very active part in, and was held in high esteem by different professional societies. He was a past-chairman of the Montana Section of AIME, past-president of the Montana Soc. of Engineers, a member of the Soc. of Economic Geologists, an active member of the American Mining Congress, and a registered professional engineer in Montana.

The officers and members of the Montana Section of AIME extend to his widow and members of his family their condolences and heartfelt sympathy and join with them in mourning the loss of a loved one; and direct that a copy of this ex-

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pression of their great esteem and sorrow be sent to his family, and that a copy be entered in the minutes of the Montana Section of the Society.

Robert F. Brown (Member 1954) suffered a fatal heart attack Jan. 11, 1960, in the Philippines, a country with which he was long associated. He first went there in 1937 and was there at the outbreak of the war when he was taken prisoner by the Japanese. After the liberation he returned to the United States. In 1955 he returned to the Philippines for A. Soriano y Cia, Mining Dept. Mr. Brown was born in Albuquerque, N.M., Nov. 15, 1903, and attended the public schools there. In 1929 he began his mining career with Dinty Moore Placer Mines, Prescott, Ariz. There followed a variety of jobs with mining companies in the West before he went with Royal Paracale Mining Co. in the Philippines.

George L. Clemens (Member 1937) died Nov. 17, 1959 at the age of 67, in Salt Lake City where he was living in retirement. Mr. Clemens was born in Cleveland, Feb. 6, 1892, and received a B.S. in mining engineering from the Case School of Applied Science in 1915. Upon graduation he went to work for Youngstown Sheet & Tube Co. as a metallurgical inspector. He held various jobs in the Midwest until joining Oglebay-Norton & Co. as a consulting engineer in 1929 and was sent by them to Russia in 1930 where he stayed until 1932. When he resumed his career in the U.S. in 1934 he moved to Denver.

E. G. Lewis (Member 1949) died a month before his 70th birthday in Ajo, Ariz., on June 18, 1959. He was born July 18, 1889 in Orange City, Iowa. His professional education was received at the University of Idaho from which he received his B.S. in mining in 1910. A large part of his professional career was spent with Phelps Dodge Corp. beginning in 1926 when he joined the Investigation Dept. at the Douglas Smelter. He moved to Ajo in 1934 and served as flotation research engineer, mill metallurgist, and mill superintendent for the New Cornelia Branch.

Ray Meade (Member 1947) died recently in Birmingham. Mr. Meade was born Oct. 22, 1891, in Jacksonville, Fla. He received his B.S. in mechanical engineering from Alabama Polytechnical Institute in 1904 and a B.S. in mining engineering from Massachusetts Institute of Technology in 1924. At the time of his death he was retired, after a long and varied career in his chosen profession.

Death claimed **Joseph A. Mecia** (Member 1939) following the crash of the Utah Construction & Mining Co. plane near Minersville, Utah, Jan. 13, 1960. Four survivors had thought that he had been killed along with Homer A. Mann at the the time of the crash. However a rescue party found him sitting near the wreckage of the plane and got him into an ambulance to take him to Cedar City. He died enroute. General vice president and manager of the mining division of Utah Construction and Mining Co., he had been with them since 1952.

Mr. Mecia was born in Monterey, Calif., Aug. 22, 1917. He received his A.B. in geology from Stanford University in 1940. During his summer vacations he worked in mines in California and Idaho. Upon graduation he became a member of the geology department of Idaho-Maryland Mines Co. for eight months. From there he went with the Bradley Mining Co. until joining Utah Construction & Mining Co.

Jared H. Miller (Member 1932) died at the age of 89 in Pasadena, Calif., Jan. 16, 1960. Dr. Miller, a native of Middlesex, Vt., was educated at Wesleyan Academy and the University of Vermont. In 1900 he was granted an M. D. degree from Baltimore Medical College. His mining connection dates from 1929 when he was president and large stockholder in the Barrus Land Co. which owns 2000 acres of iron land under a fifty year lease to Ford Motor Co. on which were developed the Blueberry Iron Mine. He was also a larger owner and manager of a tract leased to Cleveland-Cliffs Iron Co.

F. W. Parrott (Member 1955) died Dec. 30, 1959, in Wilmington, Del. At the time of his death Mr. Parrott was manager of the Technical Service Section, E. I. du Pont de Nemours & Co., the firm with which he was associated throughout his professional career. Mr. Parrott was born Feb. 5, 1914, in Coburg, Iowa. He received a B.S. degree in chemical engineering from the School of Engineering, University of Wisconsin in 1937.

H. D. Pinkney (Member 1954) died Jan. 17, 1960, in Good Samaritan Hospital, Los Angeles, after a short illness. Mr. Pinkney was utilities coordinator for the Lockheed Aircraft Corp. at the time of his death. Born May 20, 1903, in Baltimore, he was a graduate of West Virginia University. Upon graduation, in 1925, he went to Pueblo, Colo., as a mining engineer with Colorado Fuel & Iron Corp. For the next 28 years Colorado was the scene of his professional activities. In 1954 he went to Chicago as vice president in charge of operations for United Electrical Coal Co. where he remained unitl joining Lockheed in 1956.

J. G. Tate (Member 1941) was killed Oct. 23, 1959 when the car he was in struck an unoccupied vehicle standing on the highway outside of Nicosia, Cyprus. Mr. Tate was general mines superintendent for Cyprus Mines Corp. at Skouriotissa. He came to Cyprus in 1925 and remained there for the rest of his life except for three months in 1946 when Cyprus Mines sent him on an extensive trip to the United States to study various mining operations.

Gerald J. Ballmer (Member 1947), retired general superintendent of mines at Kennecott Copper Corp.'s Chino Mines Div. in New Mexico, died Mar. 9, 1960, in San Diego. He and his wife had been living in nearby Vista since his retirement in 1959. Mr. Ballmer was born Oct. 21, 1897, in Detroit and attended Capital University in Ohio from 1916 to 1917. From 1922 to 1925 he attended the New Mexico School of Mines from which he received a B.S. in geological engineering. He began his employment with Chino as an engineers' helper in 1925. Except for a two year period from 1934 to 1936 when he worked as a consulting geologist and as a geologist for the U. S. Boundary Commission, his

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entire professional career was spent with Chino.

Lees J. Burrows (Member 1947) died recently. Mr. Burrows was born April 23, 1898, in Sagunau, Michigan and attended the University of Michigan. In 1931 he began his mining career as partner-manager of Alaska Continental Gold Mines and subsequently was partner-manager in other mining holdings. At the time of his death he was manager-partner of Diamond Drill Contracting Co. in Spokane.

William W. Cowan (Member 1917) died Dec. 28, 1959, at the age of 66 in New York where he was living in retirement. Mr. Cowan was a native New Yorker and received his degree in mining engineering from Columbia University School of Mines. For many years he was associated with The Dorr Co., working, in turn, in its Wilkes-Barre, Pa., Chicago, and New York offices.

Frederick Cowans (Legion of Honor Member 1905), 82, died Sept. 7, 1959, in Pasadena, Calif. Mr. Cowans was a native of Montreal. He graduated from McGill University in 1900 and went to work for the Canadian Pacific R.R. as a surveyor. He began his carrer as a mining engineer in the following year in Silverton, B.C.

Edward H. Nutter (Legion of Honor Member 1903), 83, noted mining consultant and geologist died in a Saratoga, Calif., rest home Mar. 1, 1960. A native of Healdsburg and a graduate of Stanford University, Mr. Nutter founded the old Minerals Separation North American Corp. He helped develop the widely used selective flotation process for separating sulfides of different metals.

Necrology

Date Elected	Name	Date of Death
1921	D. H. Angus	Feb. 22, 1960
1957	Gerald F. Austin	Jan. 1, 1960
1956	Robert E. Brooks	Unknown
1897	F. P. Burrall Legion of Honor	Feb. 11, 1960
1909	Alfred P. Busey, Jr. Legion of Honor	June 22, 1959
1922	Ira F. Davis	Mar. 19, 1960
1921	H. Earl Dunn	Feb. 5, 1960
1932	Jas. B. Eldridge	Feb. 15, 1960
1955	Travis C. Frensley	June 2, 1959
1951	Paul Fullop	May 27, 1959
1930	George S. Goodale	Feb. 20, 1960
1958	Roger N. Gray	June 14, 1959
1941	J. Edwin Hill	Jan. 7, 1960
1958	G. H. Hirschfeld	Dec. 28, 1959
1956	Phillip N. Hosford	Feb. 23, 1960
1921	Howard Howie	Mar. 20, 1958
1958	J. L. Hutchinson	Jan. 7, 1960
1946	F. S. Lubrecht	Unknown
1927	K. L. Marshall	Dec. 21, 1959
1936	Armstrong Matthews	Apr. 2, 1960
1916	W. J. Mead	Jan. 16, 1960
1955	Frank E. Patterson	Jan. 5, 1960
1946	Joseph Petusky	Jan. 22, 1960
1943	Frederick C. Platt	July 11, 1958
1948	D. R. Purvis	Unknown
1946	Richard H. Richards	Dec. 20, 1959
1950	Kenneth C. Richmond	Oct. 23, 1959
1944	W. Wallace Roff	Jan. 16, 1960
1941	Gordon C. Smith	Jan. 20, 1960
1916	Walter C. Smith	Apr. 6, 1960
1936	Harry A. Strain	Feb. 26, 1960
1946	Adam J. Texter	June 29, 1959
1935	C. T. Ulrich	Feb. 28, 1960
1939	D. G. Vedder	Dec. 8, 1959
1940	Geo. W. Vreeland	Mar. 7, 1960

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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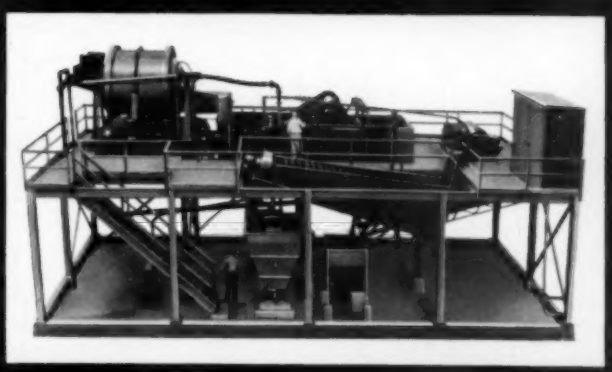

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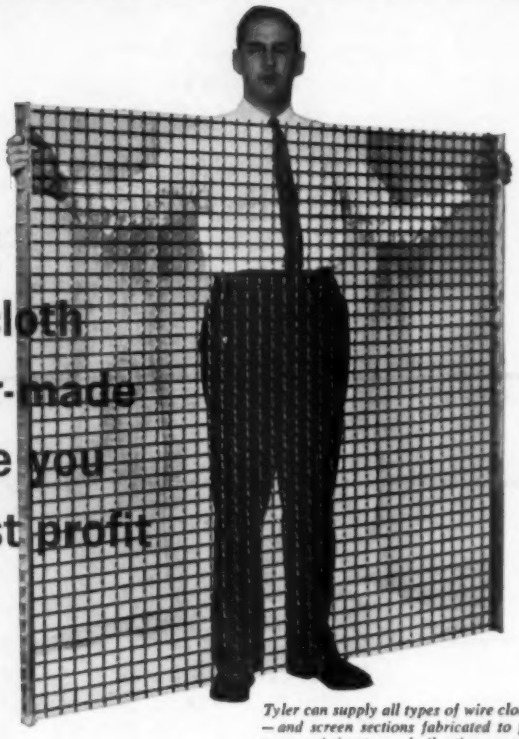

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